Consumers
Power
Company

General Offices: 212 West Michigan Avenue, Jackson, Michigan 49201 • Area Code 517 788-0550

February 22, 1978

Director of Nuclear Reactor Regulation
Att: Mr Albert Schwencer, Chief
Operating Reactors Branch No 1
US Nuclear Regulatory Commission
Washington, DC 20555

DOCKET 50-255 - LICENSE DPR-20 -
PALISADES PLANT - PROPOSED TECHNICAL
SPECIFICATIONS CHANGE - HEATUP AND
COOLDOWN CURVES

Amendment No 27 dated May 5, 1977 to the Palisades Plant Provisional Operating License limited the effective operating period for the plant heatup and cooldown curves (Technical Specification 3.1.2). This letter submits proposed Technical Specifications changes to provide heatup and cooldown curves for Cycle 3 operation. These existing curves will allow approximately one month of additional operation during Cycle 3 and, therefore, these proposed changes will be needed by May 1, 1978.

David P. Hoffman

David P Hoffman
Assistant Nuclear Licensing Administrator

CC: JGKeppler, USNRC

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CONSUMERS POWER COMPANY
Docket 50-255
Request for Change to the Technical Specifications
License DPR-20

For the reasons hereinafter set forth, it is requested that the Technical Specifications contained in Provisional Operating License DPR-20, Docket 50-255, issued to Consumers Power Company on October 16, 1972 for the Palisades Plant be changed as described in Section I below:

I. Change

Replace Technical Specifications 3.1.2 and 3.1.3 with the attached new Technical Specifications 3.1.2 and 3.1.3.

II. Discussion

The Safety Evaluation by the Office of Nuclear Reactor Regulation supporting Amendment No 27 dated May 5, 1977 to the Palisades Plant Provisional License recognized that additional testing of unirradiated reactor vessel specimens would be completed in 1977. The effective period for the heatup and cooldown operating curves was, therefore, reduced from a requested 3×10^6 MWd_t to 2.2×10^6 MWd_t. This request includes the Battelle report entitled, "Palisades Pressure Vessel Irradiation Capsule Program: Unirradiated Mechanical Properties," dated August 25, 1977, related correspondence between Consumers Power, EPRI and Battelle dated 9/16/77, 9/20/77 and 11/22/77 and an increase of the effective operating period back to 3×10^6 MWd_t. This operation will allow us to complete Cycle 3 and the evaluation of first irradiated capsule.

III. Conclusion

Based on the foregoing, both the Palisades Plant Review Committee and the Safety and Audit Review Board have reviewed the proposed changes and recommend their approval.

CONSUMERS POWER COMPANY

By R C Youngdahl

R C Youngdahl, Executive Vice President

Sworn and subscribed to before me this 22nd day of February 1978.

Sylvia B Ball

Sylvia B Ball, Notary Public
Jackson County, Michigan
My commission expires April 13, 1980.

3.1 PRIMARY COOLANT SYSTEM (Contd)

3.1.2 Heatup and Cooldown Rates

The primary coolant pressure and the system heatup and cooldown rates shall be limited in accordance with Figure 3-1, Figure 3-2 and as follows:

a. Allowable combinations of pressure and temperature for any heatup rate shall be below and to the right of the limit lines as shown on Figure 3-1. The average heatup rate shall not exceed 100°F/h in any one-hour time period.

b. Allowable combinations of pressure and temperature for any cooldown rate shall be below and to the right of the limit lines as shown on Figure 3-2. The average cooldown rate shall not exceed 100°F/h in any one-hour time period.

c. Allowable combinations of pressure and temperature for inservice testing from heatup are as shown in Figure 3-3. Those curves include allowances for the temperature change rates noted above. Interpolation between limit lines for other than the noted temperature change rates is permitted in 3.1.2a, b or c.

d. The average heatup and cooldown rates for the pressurizer shall not exceed 200°F/h in any one-hour time period.

e. Before the radiation exposure of the reactor vessel exceeds the exposure for which the figures apply, Figures 3-1, 3-2, and 3-3 shall be updated in accordance with the following criteria and procedure:

(1) US Nuclear Regulatory Commission Regulatory Guide 1.99 has been used to predict the increase in transition temperature based on integrated fast neutron flux.

If measurements on the irradiated specimens show increase above this curve, a new curve shall be constructed such that it is above and to the left of all applicable data points.

3.1 PRIMARY COOLANT SYSTEM (Contd)

3.1.2 Heatup and Cooldown Rates (Contd)

(2) Before the end of the integrated power period for which Figures 3-1, 3-2 and 3-3 apply, the limit lines on the figures shall be updated for a new integrated power period. The total integrated reactor thermal power from start-up to the end of the new power period shall be converted to an equivalent integrated fast neutron exposure ($E \geq 1$ MeV). Such a conversion shall be made consistent with the dosimetry evaluation of the initial surveillance program capsule to be removed before the beginning of the Cycle 3. For purposes of determining fluence at the reactor vessel beltline for the present fuel cycle, the following basis was established: 3.64×10^{19} nvt calculated at the reactor vessel beltline for 2540 MW_t for 40 years at a 80% load factor. This conversion has resulted in a correlation of 1.23×10^{12} nvt per 1 MWd_t.

(3) The limit lines in Figures 3-1 through 3-3 shall be moved parallel to the temperature axis in the direction of increasing temperature a distance associated with the RT_{NDT} increase during the period since the curves were last constructed. The RT_{NDT} increase will be based upon surveillance program testing of the specimens in the initial surveillance capsule.

Basis

All components in the primary coolant system are designed to withstand the effects of cyclic loads due to primary system temperature and pressure changes.[1] These cyclic loads are introduced by normal unit load transients, reactor trips and start-up and shutdown operation.

3.1 PRIMARY COOLANT SYSTEM (Contd)

3.1.2 Heatup and Cooldown Rates (Contd)

During unit start-up and shutdown, the rates of temperature and pressure changes are limited. A maximum plant heatup and cooldown rate of 100°F per hour is consistent with the design number of cycles and satisfies stress limits for cyclic operation.(2)

The reactor vessel plate and material opposite the core has been purchased to a specified Charpy V-notch test result of 30 ft-lb or greater at an NDTT of +10°F or less. The testing of base line specimens associated with the reactor surveillance program indicates that the vessel plate has the highest RT_{NDT} of plate, weld and HAZ specimens. The RT_{NDT} has been determined to be 0°F.(3) An RT_{NDT} of 0°F is used as an unirradiated value to which irradiation effects are added. In addition, this plate has been 100% volumetrically inspected by ultrasonic test using both longitudinal and shear wave methods. The remaining material in the reactor vessel, and other primary coolant system components, meets the appropriate design code requirements and specific component function and has a maximum NDTT of +40°F.(4)

As a result of fast neutron irradiation in the region of the core, there will be an increase in the NDTT with operation. The techniques used to predict the integrated fast neutron (E > 1 MeV) fluxes of the reactor vessel are described in Section 3.3.2.6 of the FSAR and also in Amendment 13, Section II, to the FSAR.

Since the neutron spectra and the flux measured at the samples and reactor vessel inside radius should be nearly identical, the measured transition

3.1 PRIMARY COOLANT SYSTEM (Contd)

3.1.2 Heatup and Cooldown Rates (Contd)

shift for a sample can be applied to the adjacent section of the reactor vessel for later stages in plant life equivalent to the difference in calculated flux magnitude. The maximum exposure of the reactor vessel will be obtained from the measured sample exposure by application of the calculated azimuthal neutron flux variation. The maximum integrated fast neutron ($E > 1$ MeV) exposure of the reactor vessel is computed to be 3.64×10^{19} nvt for 40 years' operation at 2540 MW_t and 80% load factor.[5] The predicted RT_{NDT} shift for a given fluence and copper-phosphorus weight percent has been made from a correlation for that purpose.[6] The actual shift in RT_{NDT} will be established periodically during plant operation by testing of reactor vessel material samples which are irradiated cumulatively by securing them near the inside wall of the reactor vessel as described in Section 4.5.3 and Figure 4-11 of the FSAR. To compensate for any increase in the NDTT caused by irradiation, limits on the pressure-temperature relationship are periodically changed to stay within the stress limits during heatup and cooldown.

Reference 7 provides a procedure for obtaining the allowable loadings for ferritic pressure-retaining materials in Class 1 components. This procedure is based on the principles of linear elastic fracture mechanics and involves a stress intensity factor prediction which is a lower bound of static, dynamic and crack arrest critical values. The stress intensity factor computed[7] is a function of RT_{NDT}, operating temperature, and vessel wall temperature gradients.

Pressure-temperature limit calculational procedures for the reactor coolant pressure boundary are defined in Reference 8 based upon Reference 7.

3.1 PRIMARY COOLANT SYSTEM (Contd)

3.1.2 Heatup and Cooldown Rates (Contd)

The limit lines of Figures 3-1 through 3-3 consider a 54 psi pressure allowance to account for the fact that pressure is measured in the pressurizer rather than at the vessel belt line. In addition, for calculational purposes, 5°F and 30 psi were taken as measurement error allowances for temperature and pressure, respectively. By Reference 7, reactor vessel wall locations at 1/4 and 3/4 thickness are limiting. It is at these locations that the crack propagation associated with the hypothetical flaw must be arrested. At these locations, fluence attenuation and thermal gradients have been evaluated. During cooldown, the 1/4 thickness location is always more limiting in that the RT_{NDT} is higher than that at the 3/4 thickness location and thermal gradient stresses are tensile there. During heatup, either the 1/4 thickness or 3/4 thickness location may be limiting depending upon heatup rate.

Figures 3-1 and 3-2 define stress limitations only from a fracture mechanic's point of view.

Other considerations may be more restrictive with respect to pressure-temperature limits. For normal operation, other inherent plant characteristics may limit the heatup and cooldown rates which can be achieved. Pump parameters and pressurizer heating capacity tends to restrict both normal heatup and cooldown rates to less than 60°F per hour.

The revised pressure-temperature limits are applicable to reactor vessel inner wall fluences of up to 3.7×10^{18} nvt or approximately 3.0×10^{6} MWd of thermal reactor power. The application of appropriate fluence attenuation factors at the 1/4 and 3/4 thickness locations results in fluences

3.1 PRIMARY COOLANT SYSTEM (Contd)

3.1.2 Heatup and Cooldown Rates (Contd)

of 2.26×10^{18} nvt and 5.2×10^{17} nvt, respectively. From Reference 6, these are consistent with RT_{NDT} shifts of 114°F and 55°F, respectively. The criticality condition which defines a temperature below which the core cannot be made critical (strictly based upon fracture mechanics' considerations) is RT_{NDT} + 132°F. The most limiting wall location is at 1/4 thickness. The minimum criticality temperature (246°F) is the minimum permissible temperature for the inservice system hydrostatic pressure test. That temperature is calculated based upon 2100 psig operation pressure.

The restriction of heatup and cooldown rates to 100°F/h and the maintenance of a pressure-temperature relationship to the right of the heatup, cooldown and inservice test curves of Figures 3-1, 3-2, and 3-3, respectively, ensures that the requirements of References 6, 7, 8 and 9 are met. The core operational limit applies only when the reactor is critical.

The criticality temperature is determined per Reference 8 and the core operational curves adhere to the requirements of Reference 9. The inservice test curves incorporate allowances for the thermal gradients associated with the heatup curve used to attain inservice test pressure. These curves differ from heatup curves only with respect to margin for primary membrane stress.(7) For heatup rates less than 60°F/h, the hypothetical 0°F/h (isothermal heatup) at the 1/4 T location is controlling and heatup curves converge. Cooldown curves cross for various cooldown rates, thus a composite curve is drawn. Due to the shifts in RT_{NDT}, NDTT requirements associated with nonreactor vessel materials are, for all practical purposes, no longer limiting.

3.1 PRIMARY COOLANT SYSTEM (Contd)

3.1.2 Heatup and Cooldown Rates (Contd)

References

(1) FSAR, Section 4.2.2

(2) ASME Boiler and Pressure Vessel Code, Section III, N-415

(3) Battelle Columbus Laboratories Report, "Palisades Pressure Vessel Irradiation Capsule Program: Unirradiated Mechanical Properties," August 25, 1977

(4) FSAR, Section 4.2.4

(5) FSAR, Amendment 15

(6) US Nuclear Regulatory Commission, Regulatory Guide 1.99, "Effects of Residual Elements on Predicted Radiation Damage to Reactor Vessel Materials," July 1975

(7) ASME Boiler and Pressure Vessel Code, Section III, Appendix G, "Protection Against Non-Ductile Failure," 1974 Edition

(8) US Atomic Energy Commission Standard Review Plan, Directorate of Licensing, Section 5.3.2, "Pressure-Temperature Limits."

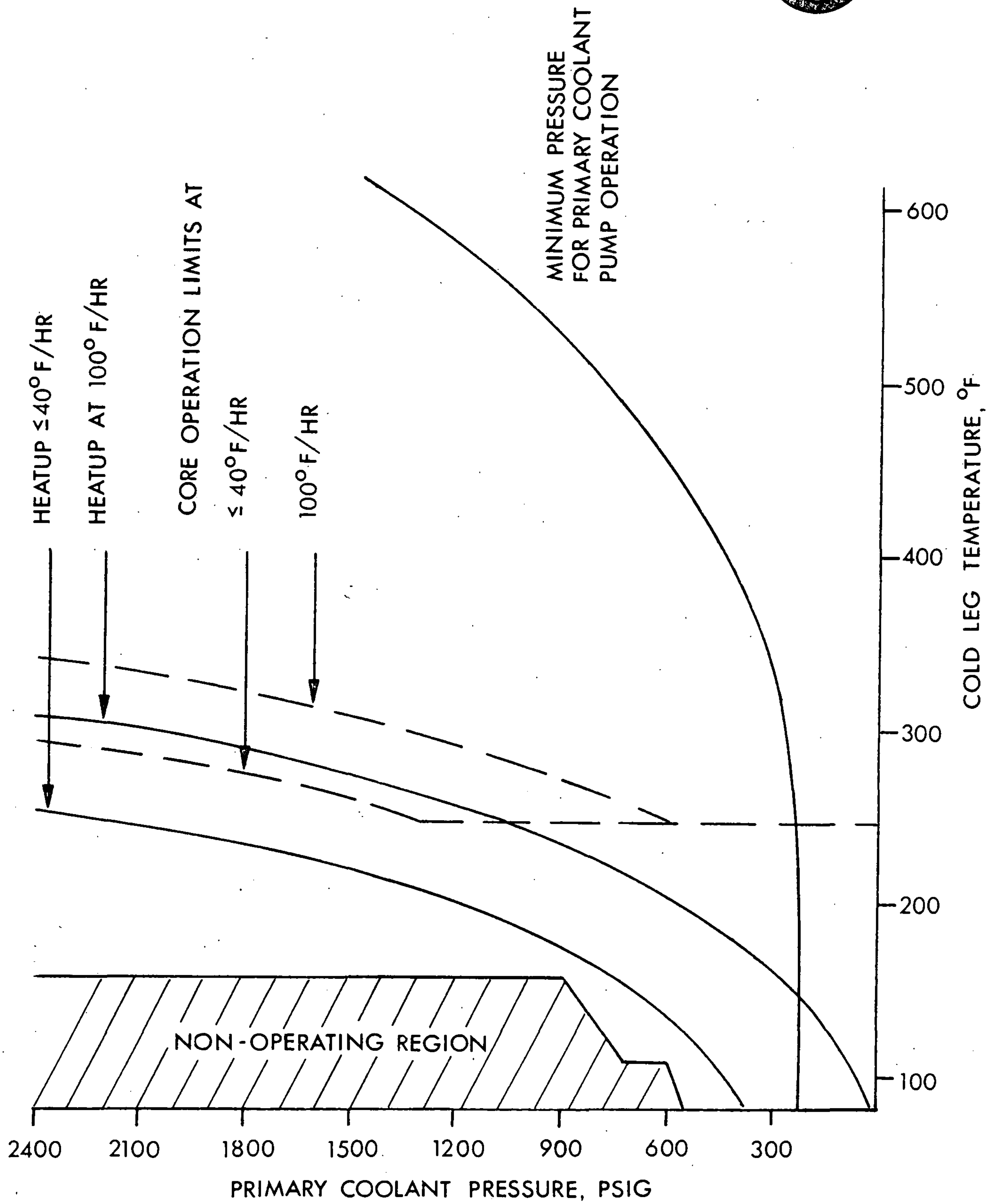
(9) 10 CF Part 50, Appendix G, "Fracture Toughness Requirements," August 31, 1973.

3.1.3 Minimum Conditions for Criticality

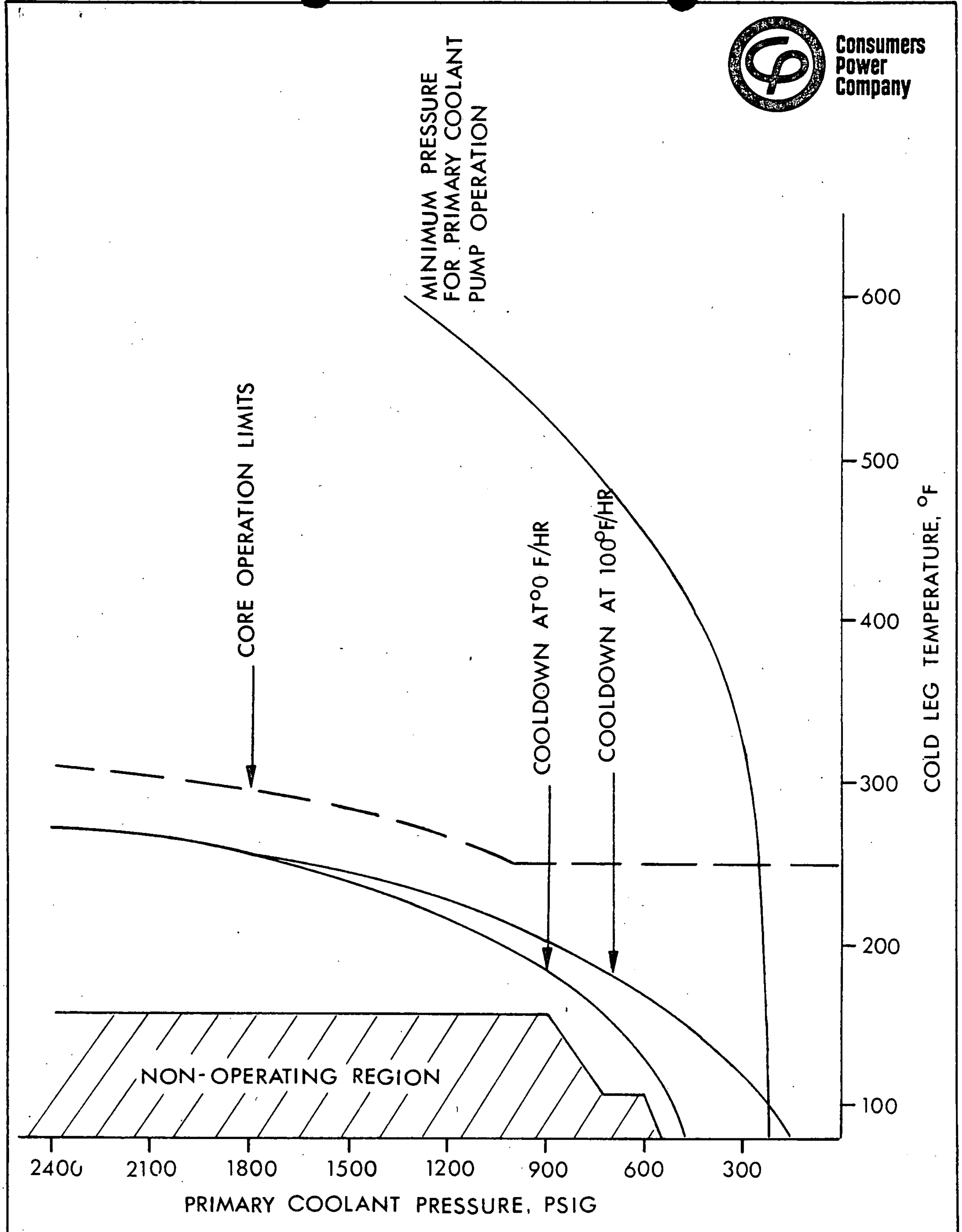
a. Except during low-power physics test, the reactor shall not be made critical if the primary coolant temperature is below 525°F.

b. In no case shall the reactor be made critical if the primary coolant temperature is below RT_{NDT} + 132°F.

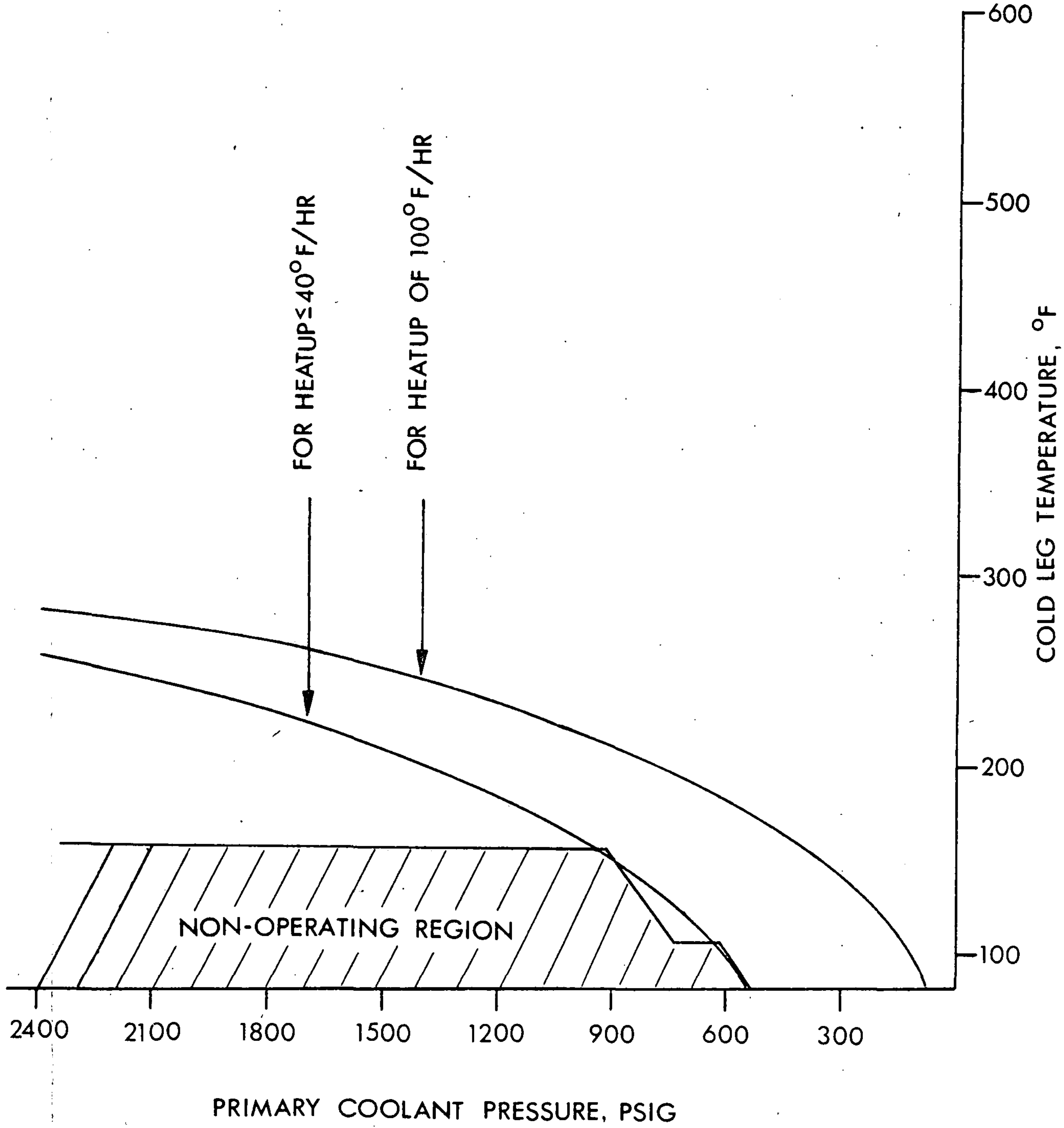
c. When the primary coolant temperature is below the minimum temperature specified in "a" above, the reactor shall be subcritical by an amount equal to or greater than the potential reactivity insertion due to depressurization.



PALISADES PLANT TECH SPEC	PRESSURE-TEMPERATURE RELATIONSHIP DURING HEATUP-TO 3.0×10^6 MWDT FIGURE 3-1	DATE: AMEND. NO:



PALISADES PLANT TECH SPEC	PRESSURE-TEMPERATURE RELATIONSHIP DURING COOLDOWN - TO 3.0×10^6 MWDT FIGURE 3-2	DATE: AMEND. NO:



PALISADES PLANT TECH SPEC	PRESSURE-TEMPERATURE RELATIONSHIP INSERVICE TEST - TO 3.0 X 10^6 MWDT FIGURE 3-3	DATE: AMEND. NO:

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3.1 PRIMARY COOLANT SYSTEM (Contd)

3.1.3 Minimum Conditions for Criticality (Contd)

d. No more than one control rod at a time shall be exercised or withdrawn until after a steam bubble and normal water level are established in the pressurizer.

e. Primary coolant boron concentration shall not be reduced until after a steam bubble and normal water level are established in the pressurizer.

Basis

At the beginning of life of the initial fuel cycle, the moderator temperature coefficient is expected to be slightly negative at operating temperatures with all control rods withdrawn.[1] However, the uncertainty of the calculation is such that it is possible that a slightly positive coefficient could exist.

The moderator coefficient at lower temperatures will be less negative or more positive than at operating temperature.[1, 2] It is, therefore, prudent to restrict the operation of the reactor when primary coolant temperatures are less than normal operating temperature ($\geq$ 525°F). Assuming the most pessimistic rods out moderator coefficient, the maximum potential reactivity insertion that could result from depressurizing the coolant from 2100 psia to saturation pressure at 525°F is 0.1% $\Delta\rho$.

During physics tests, special operating precautions will be taken. In addition, the strong negative Doppler coefficient[3] and the small integrated $\Delta\rho$ would limit the magnitude of a power excursion resulting from a reduction of moderator density.

3.1 PRIMARY COOLANT SYSTEM (Contd)

3.1.3 Minimum Conditions for Criticality (Contd)

The requirement that the reactor is not to be made critical below RT_{NDT} + 132°F provides increased assurance that the proper relationship between primary coolant pressure and temperature will be maintained relative to the NDTT of the primary coolant system. Heatup to this temperature will be accomplished by operating the primary coolant pumps.

If the shutdown margin required by Specification 3.10.1 is maintained, there is no possibility of an accidental criticality as a result of an increase of moderator temperature or a decrease of coolant pressure.

Normal water level is established in the pressurizer prior to the withdrawal of control rods or the dilution of boron so as to preclude the possible overpressurization of a solid primary coolant system.

References

(1) FSAR, Table 3-2

(2) FSAR, Table 3-6

(3) FSAR, Table 3-3

FINAL REPORT

on

PALISADES PRESSURE VESSEL IRRADIATION
CAPSULE PROGRAM: UNIRRADIATED
MECHANICAL PROPERTIES

to

CONSUMERS POWER

August 25, 1977

by

J. S. Perrin and E. O. Fromm

BATTELLE
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

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FINAL REPORT

on

PALISADES PRESSURE VESSEL IRRADIATION CAPSULE PROGRAM: UNIRRADIATED MECHANICAL PROPERTIES

to

CONSUMERS POWER

from

BATTELLE

Columbus Laboratories

August 25, 1977

SUMMARY

A pressure vessel surveillance program is being conducted for the Palisades reactor by Battelle's Columbus Laboratories. This report summarizes the preirradiation Charpy V-notch impact and tensile properties of base metal, weld metal, and heat affected zone metal specimens for the surveillance program. In addition, the drop weight properties of base metal specimens were also determined. The results will be used in the future as baseline data in determining the shift in impact and tensile properties for samples being irradiated in capsules in the reactor.

INTRODUCTION

Irradiation of materials such as the pressure vessel steels used in reactors causes changes in the mechanical properties, including tensile, impact, and fracture toughness. These effects have been well documented in the technical literature.[1-7] Tensile properties show a decrease of both uniform elongation and reduction in area accompanied by an increase in yield strength and ultimate tensile strength with increasing neutron exposure. The impact properties as determined by the Charpy V-notch impact test show a shift of the complete Charpy energy-temperature curve reflecting the brittle-failure temperature range extending to higher temperatures. In addition, the upper shelf of the Charpy curve shows a drop in energy level.

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(1) References at end of text.

Commercial nuclear power reactors are put into operation with reactor pressure vessel surveillance programs. The purpose of the surveillance program associated with a reactor is to monitor the changes in mechanical properties as a function of neutron exposure. The surveillance program includes a determination of both the preirradiation base line mechanical properties and periodic determinations of the irradiated mechanical properties. The materials included in the present surveillance program are base metal, weld metal, and heat-affected-zone (HAZ) metal from the actual components used in fabricating the vessel.

The irradiated mechanical properties are determined periodically by testing specimens from surveillance capsules. These capsules typically contain neutron flux monitors, Charpy impact specimens, and tensile specimens. Capsules are located between the inner wall of the pressure vessel and the reactor core, so the specimens receive an accelerated neutron exposure. Capsules are periodically removed, and sent to a hot laboratory for disassembly and specimen evaluation.

The Palisades reactor pressure vessel surveillance program is described in a report issued by Combustion Engineering[8], and is based on ASTM E185-73, "Surveillance Tests on Structural Materials in Nuclear Reactors".[9] At the time of initial operation of the reactor, the pressure-temperature operating curves were based on the NDT temperature of the limiting materials. During the life of the reactor, the operating curves are to be revised to account for the shift in mechanical properties determined by Charpy impact tests.

The present report describes the preirradiation base line tensile and Charpy impact properties of the three materials being used in the surveillance capsule program. The mechanical properties of the Charpy and tensile specimens were determined following the general recommendations of ASTM E185-73. In addition, the NDT temperature for the base metal was established from drop weight specimens tested in accordance with ASTM E208-69, "Conducting Drop-Weight Test to Determine Nil-Ductility Transition Temperature of Ferritic Steels".[10]

SPECIMEN PREPARATION

The base metal of the reactor pressure vessel is SA-302 Grade B. Mechanical property specimens were prepared from actual vessel plate in accordance with CE specifications and provided to Consumers Power.[8] All specimens were made from flat slabs taken parallel to the plate surfaces and at the 1/4 plate thickness.

Longitudinal base metal Charpy, tensile, and drop weight specimens were oriented with the major axis of the specimen parallel to the principal rolling direction of the plate and parallel to the surface of the plate. Transverse base metal Charpy and tensile specimens were orientated with the major axis of the specimen perpendicular to the principal rolling direction and parallel to the surface of the plate. Longitudinal weld metal Charpy and tensile specimens were oriented with the major axis of the specimen parallel to the direction of the weld and parallel to the surface of the weld. Transverse weld metal and heat-affected-zone specimens were oriented with the major axis of the specimen perpendicular to the direction of the weld and parallel to the surface of the weld.

The axis of the notch of all base metal and weld metal Charpy impact specimens was perpendicular to the surface of the plate or weld and the axis of the notch of all heat-affected-zone Charpy impact specimens was parallel to the surface of the plate.

Compositional analyses of the materials used in fabrication of the specimens are tabulated in Appendix A.

The drop weight specimen used for the program is shown in Figure 1. It is based upon the design recommended in ASTM E208-69[10] for the P-3 type specimen. The Charpy impact specimen is shown in Figure 2 and is the standard specimen recommended in ASTM E23-72.[9] The tensile specimen design is shown in Figure 3. It has a nominal 0.250-in. gage diameter and a nominal 1.00-in. gage length.

EXPERIMENTAL PROCEDURES

This section describes the experimental procedures used in the determination of the drop weight, Charpy impact and tensile properties. All testing was conducted at Battelle's Columbus Laboratories according to applicable ASTM procedures. The data for the program are recorded in BCL Laboratory Record Book No. 32899.

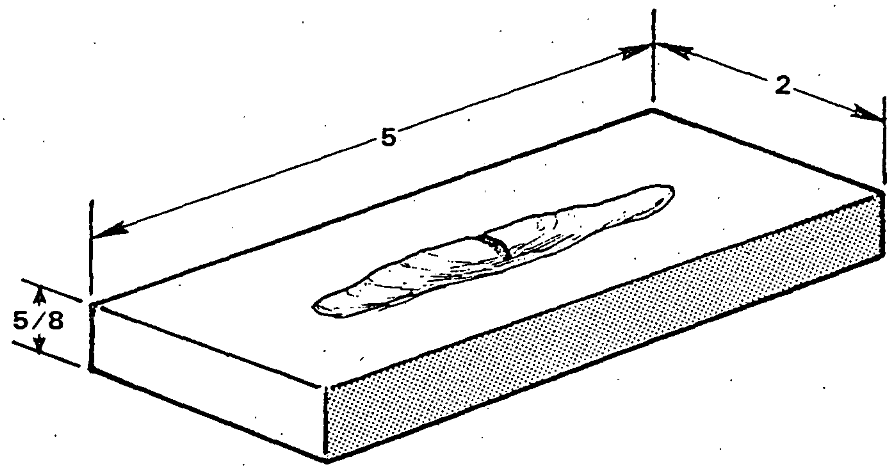


FIGURE 1. SKETCH OF P-3 TYPE DROP WEIGHT SPECIMEN

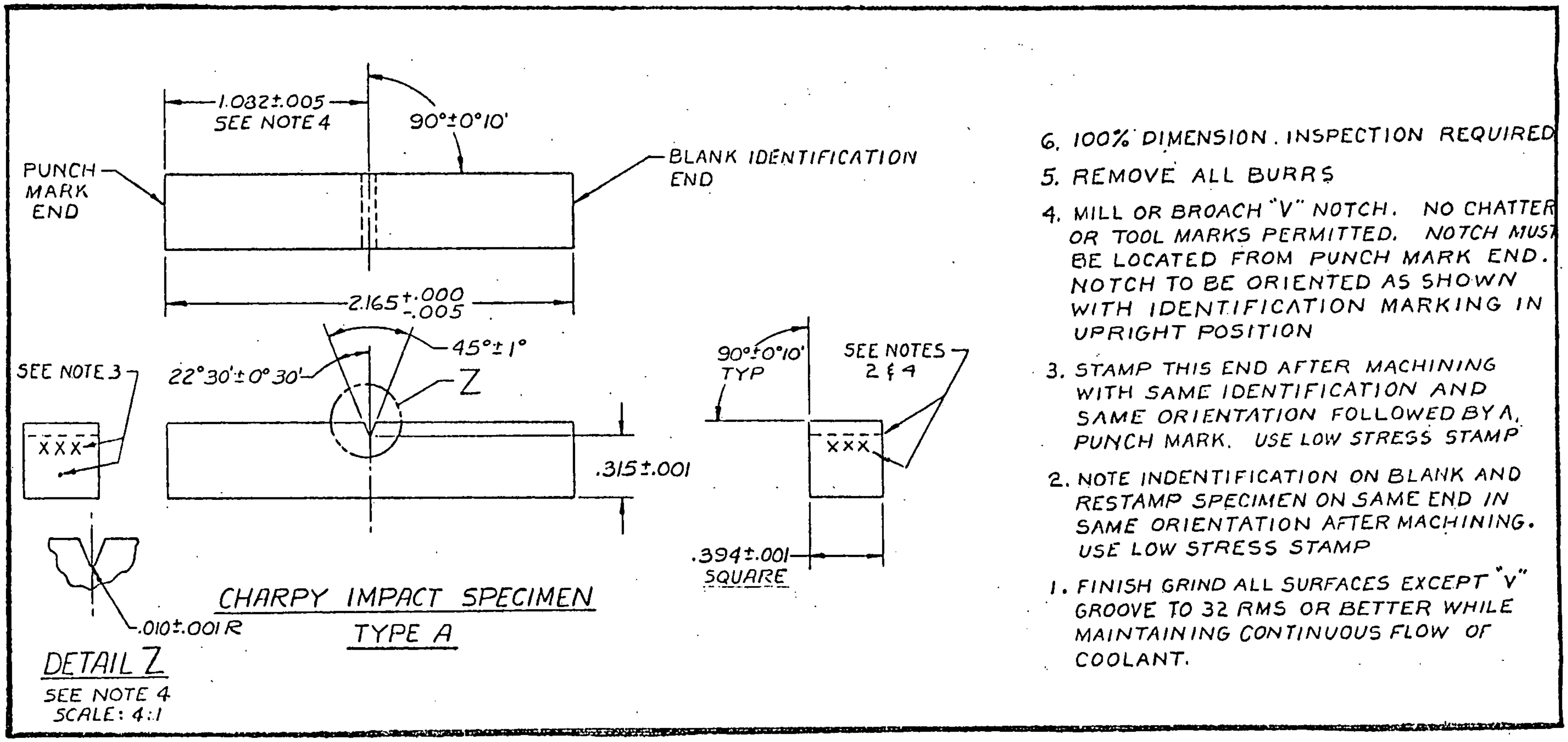
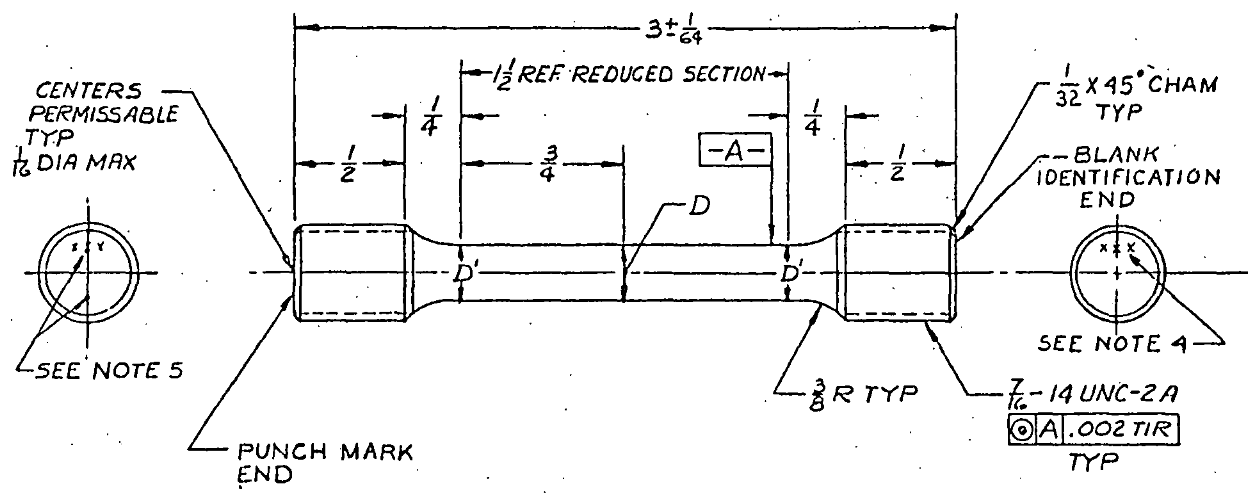


FIGURE 2. CHARPY V-NOTCH IMPACT SPECIMEN



6. 100% DIMENSIONAL INSPECTION REQUIRED.
5. STAMP OPPOSITE END AFTER MACHINING WITH SAME IDENTIFICATION FOLLOWED BY A PUNCH MARK. USE LOW STRESS STAMP.
4. NOTE IDENTIFICATION ON BLANK AND RESTAMP SPECIMEN ON SAME END AFTER MACHINING
3. POLISH REDUCED SECTION & RADIUS TO 32 RMS OR BETTER - REMAINDER AS MACHINED.
2. D' = ACTUAL 'D' DIAMETER +.002 TO +.005 AT ENDS OF REDUCED SECTION DECREASING AND BLENDED TO 'D' AT CENTER
1. D = .250 ± .001 DIA AT CENTER OF REDUCED SECTION

FIGURE 3. TENSILE SPECIMEN

Drop-Weight Properties

The drop-weight tests were conducted using the P-3 type specimen shown in Figure 1. The specimens were fabricated from base longitudinal metal and were tested in the BCL Drop Weight Machine according to procedures based upon ASTM Method E208-69.[10] The verification of the machine was performed following the requirements of ASTM Method E208-69.

The drop weight machine is shown schematically in Figure 4. It consists of a vertically guided, free falling weighted tup and a rigidly supported anvil which provides for the loading of a rectangular plate specimen as a simple beam under the falling weight. The rails are held in a vertical position in a fixed relationship to the base. The rails guide the weighted tup so that it strikes the specimen at the proper location. The impact energy of the weighted tup was 300 ft-lb in all tests.

The specimen was immersed in an agitated low temperature bath consisting of methyl alcohol and dry ice for a minimum of 45 minutes prior to testing. The temperature of the bath was held to ± 2 F during the 45-minute soak time. The specimen was then removed from the bath, placed on the anvil, and tested within 20 seconds. The resultant "break or no break" performance was then noted.

Charpy Impact Properties

The impact properties were determined using a standard 240 ft-lb Wiedemann Baldwin impact machine in accordance with the recommendations of ASTM Method E-23-72.[11] The machine was verified according to the applicable sections of this standard. In addition, the proof test of the machine was performed using standard Charpy V-notch specimens purchased from the U.S. Army Materials Research Agency. The results of the standard specimens are given in Table 1.

The velocity of the hammer at the striking position is 17.0 ft/sec. The 240 ft-lb range was used for all tests. The energy loss due to friction of the machine was determined daily during use of the impact machine. This was done by the following: (a) releasing the pendulum from the 240 ft-lb upright position with no specimen in the machine and determining the indicated energy value is 0 ft-lb; (b) without resetting the pointer, again releasing the pendulum from the 240 ft-lb upright position and permitting it to swing 11 half cycles. After the pendulum starts its 11th half cycle, the pointer is moved to between 12 and 24 ft-lbs and it is determined that the indicated value, divided by 11, does not exceed 0.4 percent (0.96 ft-lb) of the 240 ft-lb capacity.

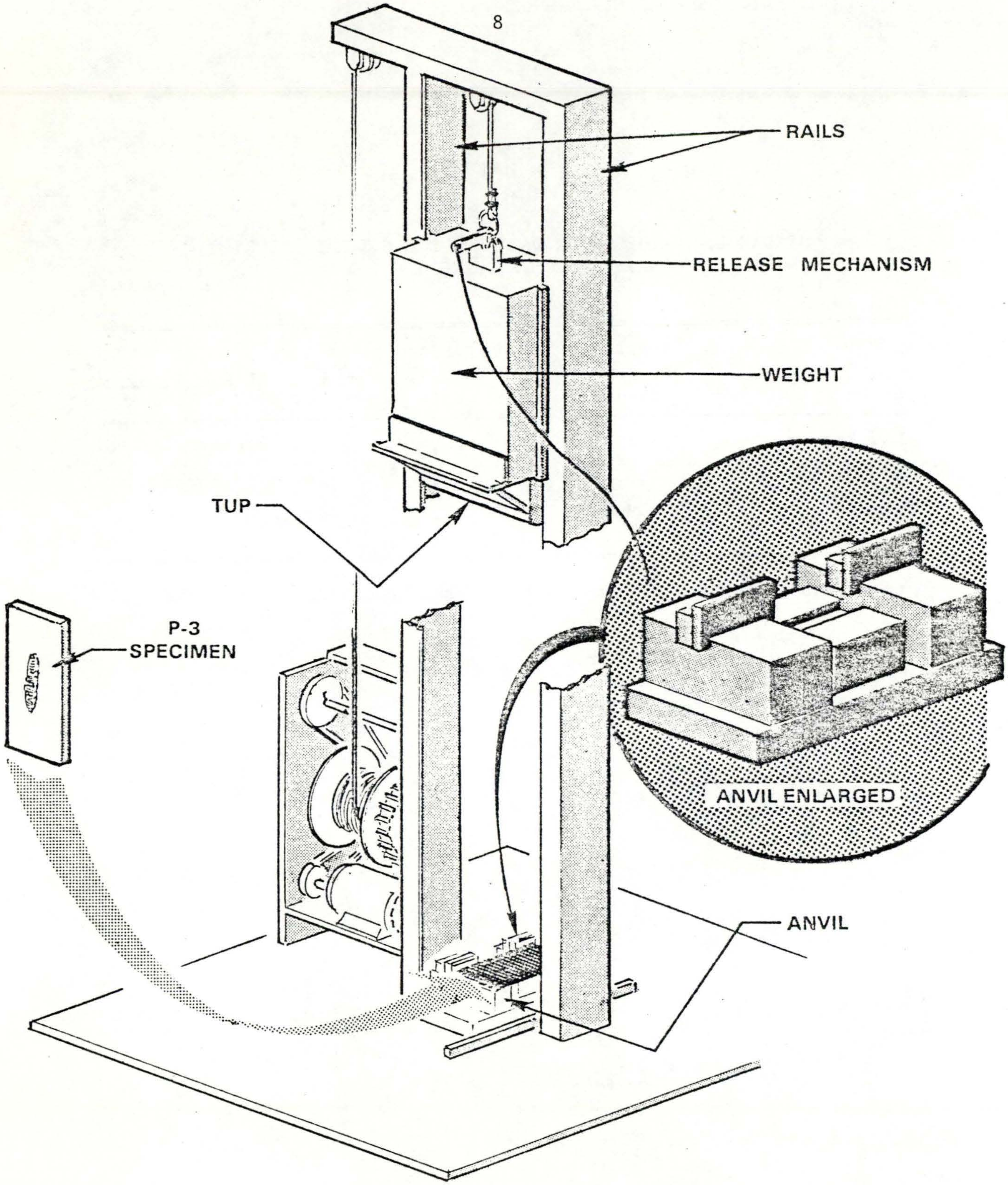


FIGURE 4. SKETCH OF BCL DROP WEIGHT MACHINE

TABLE 1. CALIBRATION DATA FOR BCL HOT LABORATORY CHARPY IMPACT MACHINE

Group	Average BCL Energy, ft-lb	Standard Energy,[a] ft-lb	Variation Actual	Variation Allowed
Low Energy	12.2	12.4	-0.2 ft-lb	±1 ft-lb
Medium Energy	50.6	52.9	-4.3%	±5%
High Energy	69.4	71.6	-3.1%	±5%

(a) Established by U.S. Army Materials and Mechanics Research Center.

The ASTM recommendations for specimen temperature control were followed. The low temperature bath consisted of agitated methyl alcohol cooled with additions of liquid nitrogen. The container was a Dewar flask which contained a grid to keep the specimens at least 1 in. from the bottom with a minimum of 1 in. of liquid over the specimens. The Charpy specimens were held at temperature for a minimum of at least the ASTM recommended time. The tests above room temperature were conducted in a similar manner except that a temperature controlled oil bath was used.

The specimens were transferred from the temperature bath to the anvil of the impact machine by means of tongs that had also been brought to temperature in the bath. The specimens were removed from the bath and impacted in less than 5 sec. The energy required to break each specimen was recorded and plotted as a function of test temperature as the testing proceeded.

Lateral expansion was determined from measurements made with a lateral expansion gage. Fracture appearance was estimated from comparison of the specimen fracture surface to an ASTM fracture appearance chart.[11]

Tensile Properties

The design of the tensile specimens is shown in Figure 3. The tensile tests were conducted on a screw-driven Instron testing machine having a 20,000 lb capacity. Crosshead speeds of 0.005 and 0.05 in. per min were used. A strain gage extensometer was attached to the specimen gage length. The strain gage unit senses the differential movement of two extensometer extension arms attached to the specimen gage length 1 in. apart. The extension arms are required for thermal protection of the strain gage unit during the elevated temperature tests. Figure 5 shows the extensometer extension arms and strain gage assembly used for tensile testing. The strain gage unit is shown at the bottom of the figure next to the region of the extensometer arms where the unit is attached during testing. The extensometer was calibrated before testing using an Instron high-magnification drum-type extensometer calibrator.

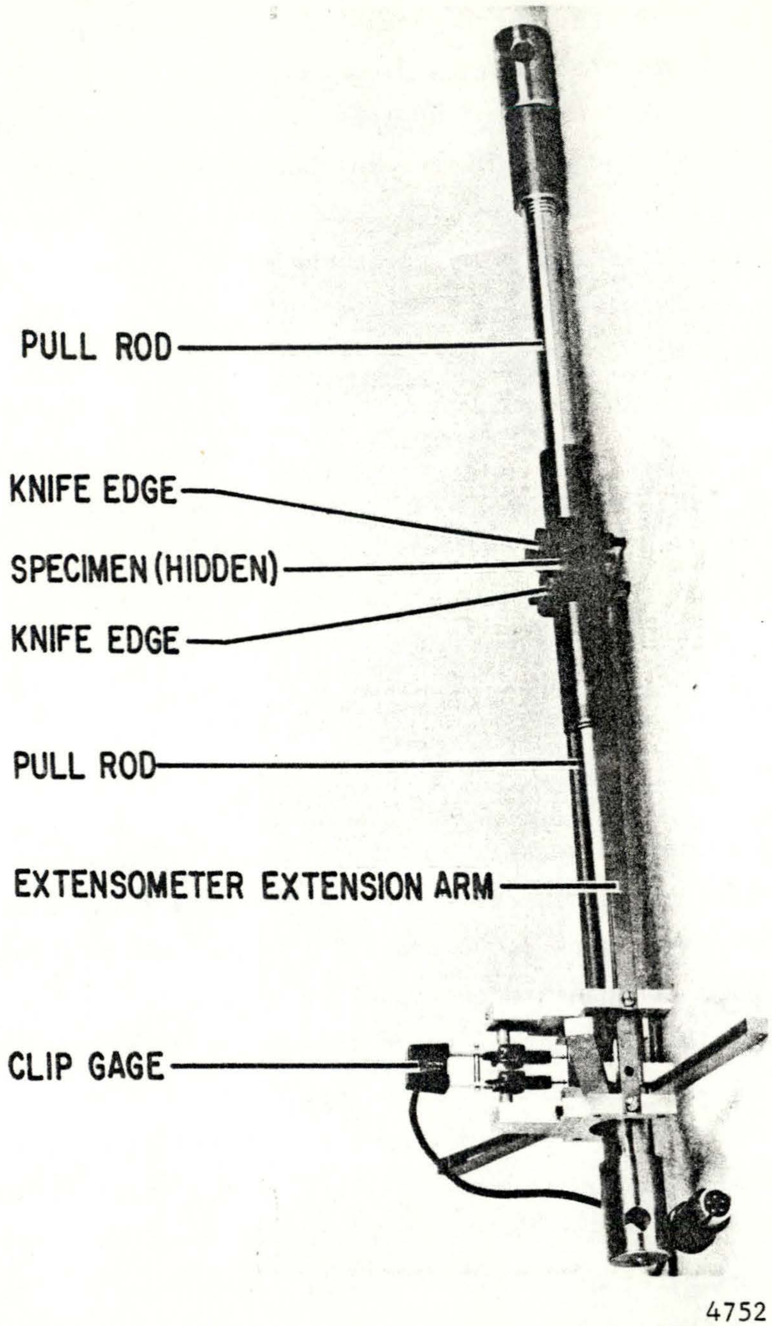


FIGURE 5. LOAD TRAIN USED FOR DETERMINATION OF TENSILE PROPERTIES

Specimen is located under extensometer knife edges in center of photograph. Clip-on strain gage attached to extensometer arms is shown in lower region of photograph.

The specimens were pulled in a load-elongation mode at a crosshead speed of 0.005 in. per min until the vicinity of maximum load. The runs were then finished in a load-time mode at a crosshead speed of 0.05 in. per min.

The tensile specimens were tested at room temperature, 535 F, and 565 F. The elevated temperature tensile tests were conducted using a split test furnace. The specimens were held at temperature for 20 minutes before testing to stabilize the temperature. Temperature was monitored using two Chromel-Alumel thermocouples directly attached within the gage section of the specimen. Temperature was controlled within $\pm$5 F of the test temperature throughout the test period.

The load-extension data were recorded on the testing machine strip chart. The yield strength, ultimate tensile strength, and total elongation were determined from these charts. The reduction in area was determined from specimen measurements of the necked down area using a blade micrometer.

RESULTS AND DISCUSSION

Drop Weight Properties

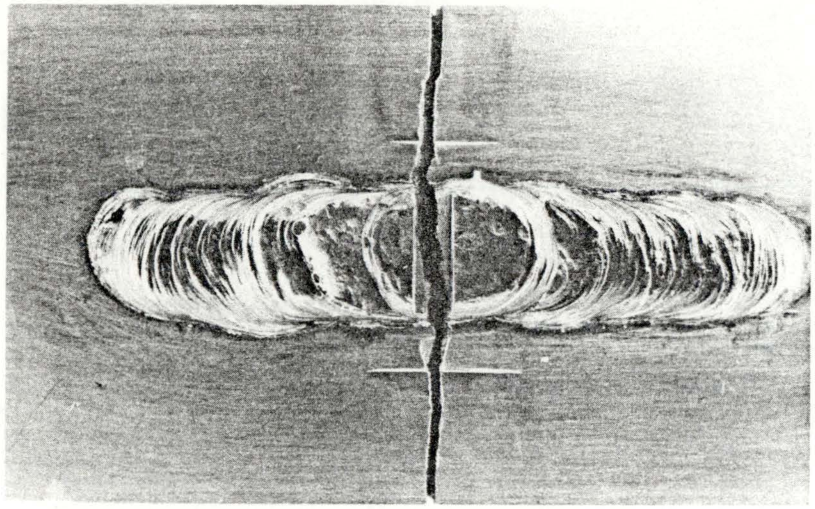
The results of the drop weight tests for the Palisades specimens are listed in Table 2. In the drop weight test, the NDT temperature is defined as the highest temperature at which a specimen breaks, with a pair of specimens exhibiting "no break" behavior at a temperature 10 F higher. As indicated in the table, duplicate drop weight tests were conducted at 10 F intervals from -30 F to 0 F. Based on the "break, no break" behavior, the NDT for the base longitudinal metal was -10 F. This is 20 F higher than that reported by the reactor vendor for this material.(8) The table of drop weight data from the present program shows that at -20 F, one specimen exhibited "break" and one "no break" performance. If both had exhibited "no break" performance, then the NDT temperature would have been -30 F as reported by the vendor, and tests at -10 F and 0 F would not have been performed.

Post-test photographs of the drop weight specimens are given in Figures 6 through 9. The "break" or "no break" performance is specified for each specimen.

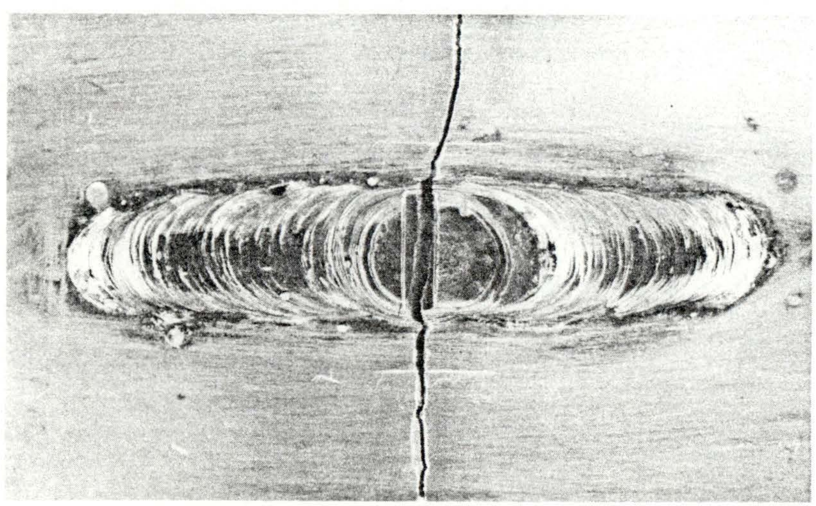
TABLE 2. DROP WEIGHT RESULTS

Specimen Identification	Test Temperature, F	Results of Test[(a)]
1C1	-30	Break
1C2	-30	Break
1C5	-20	No Break
1C7	-20	Break
1CA	-10	Break
1CB	-10	No Break
1C3	0	No Break
1CC	0	No Break

(a) Break - Fracture to one or both edges of tension surface.
No Break - Visible crack in crack starter weld bead but not propagated to either edge of tension surface.

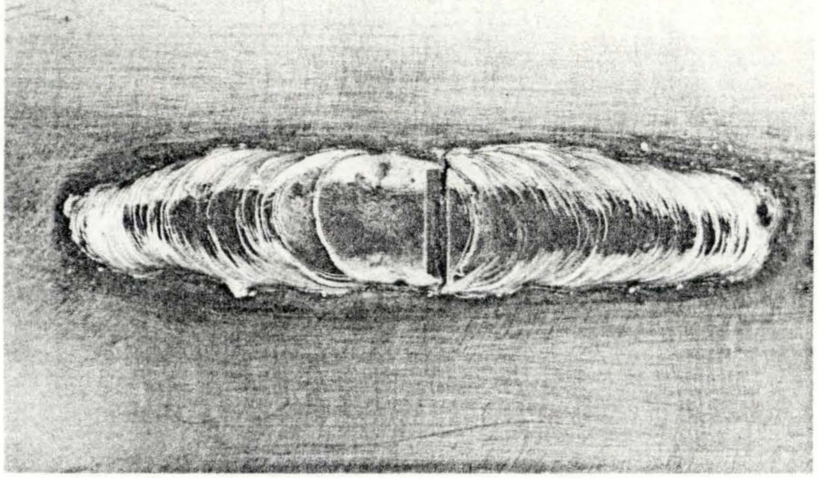


1C1
"Break"

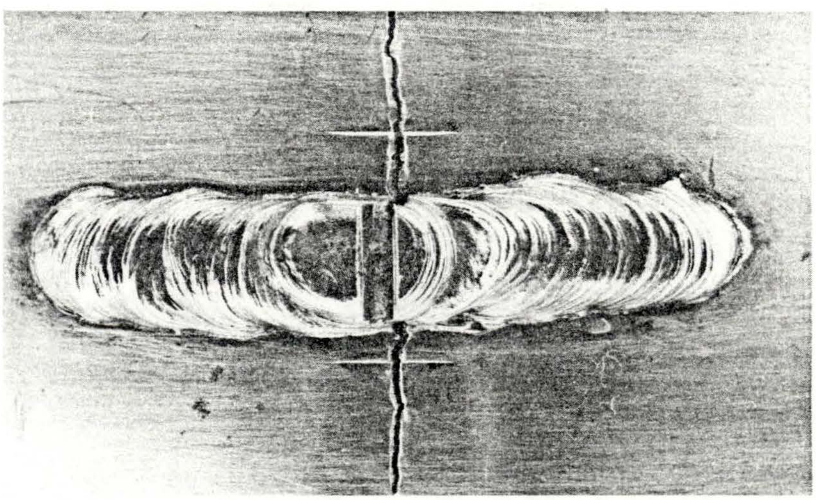


1C2
"Break"

FIGURE 6. PHOTOGRAPHS OF DROP WEIGHT SPECIMENS TESTED AT -30F

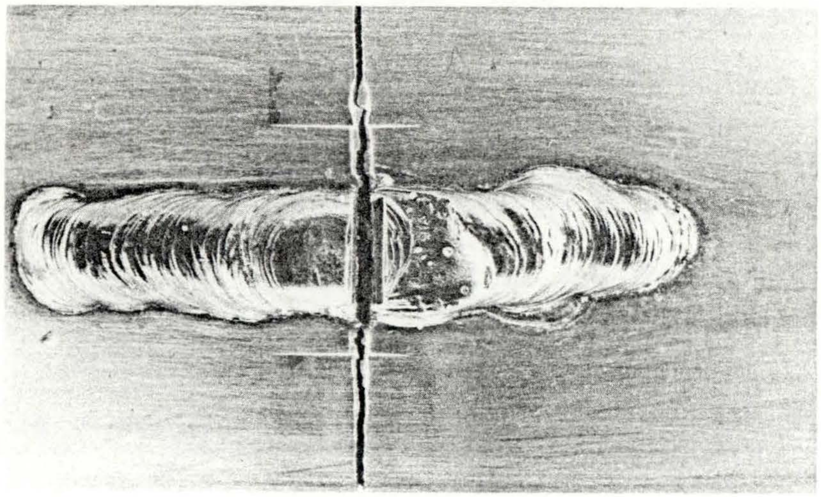


1C5
"No Break"

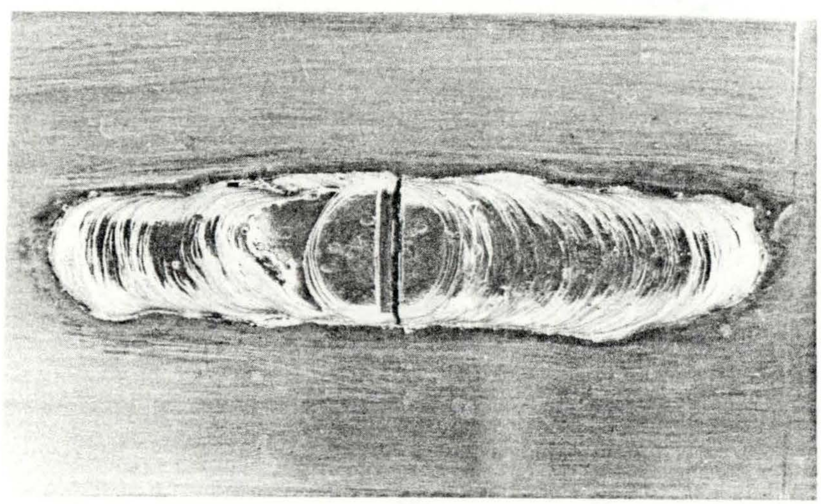


1C7
"Break"

FIGURE 7. PHOTOGRAPHS OF DROP WEIGHT SPECIMENS TESTED AT -20 F

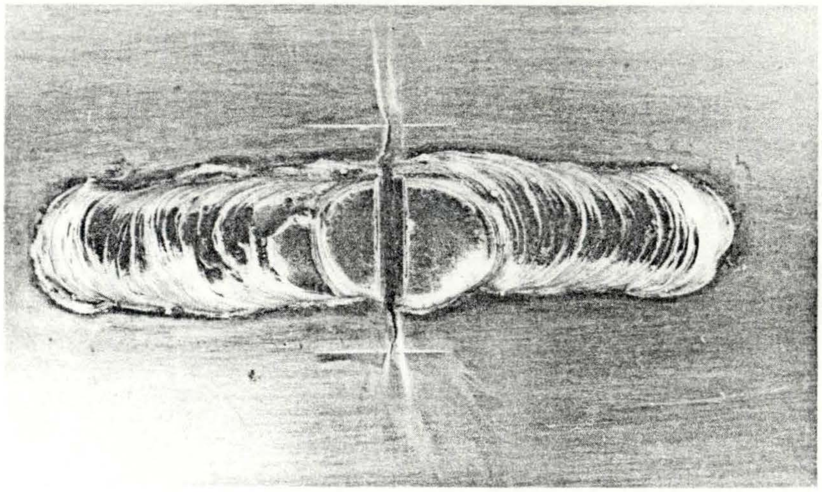


1CA
"Break"

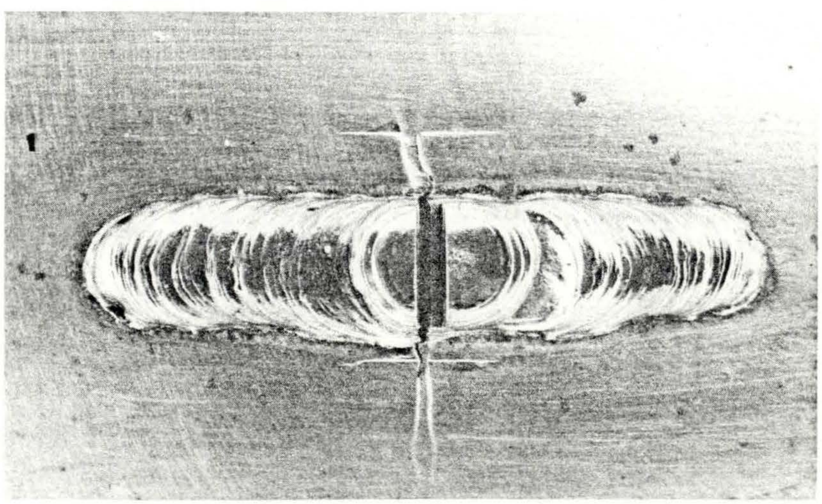


1CB
"No Break"

FIGURE 8. PHOTOGRAPHS OF DROP WEIGHT SPECIMENS TESTED AT -10F



1C3
"No Break"



1CC
"No Break"

FIGURE 9. PHOTOGRAPHS OF DROP WEIGHT SPECIMENS TESTED AT 0F

Charpy Impact Properties

The impact properties determined as a function of temperature are listed in Tables 3 through 6. In addition to the impact energy values, the tables also list the measured values of lateral expansion and the estimated fracture appearance for each specimen. The lateral expansion is a measure of the deformation produced by the striking edge of the impact machine hammer when it impacts the specimen. It is the change in specimen thickness of the section directly adjacent to the notch location. The fracture appearance is a visual estimate of the amount of shear or ductile type of fracture appearing on the specimen fracture surface.

The impact data listed in Tables 3 through 6 are graphically shown in Figures 10 through 13. These figures show the change in impact properties as a function of temperature. Of particular interest is the temperature corresponding to the impact energies of 30 and 50 ft-lbs. The energy level of the upper shelf is also of interest. If the upper shelf energy is relatively low (e.g. 50 ft-lb or lower), the possibility of failure by low energy ductile tearing is greater. In terms of fracture mechanics, a lower upper shelf is accompanied by low values of K_{Ic}, the plane strain fracture toughness.

Table 7 summarizes the 30 and 50 ft-lb transition temperatures and the upper shelf energies for the reactor. The 50 ft-lb transition temperature ranges from -50 F (weld metal) to 55 F (base metal-transverse). The upper shelf energy level levels are all above 100 ft-lb.

Figures 14 through 17 show the fracture surfaces of the Charpy specimens. Figure 14, as an example, shows how the fracture surface changes as the test temperature is increased for the base metal-longitudinal specimens. The -100 F specimen (147) shows an almost flat fracture surface with essentially 0 percent shear fracture appearance. This specimen absorbed only 3.0 ft-lb of energy during the impact test, a typically low value for the low temperature, brittle region of the Charpy curve. As can be seen in the figure, the amount of lateral expansion is quite small, and was measured as being only 4.5 mils. As the test temperature is increased, specimens show an increasing amount of shear fracture appearance. The +150 F specimen (142) fracture surface is typical of the type seen at the higher temperature end of the Charpy transition curve.

TABLE 3. CHARPY V-NOTCH IMPACT RESULTS FOR BASE METAL PLATE NO. D3803-1, LONGITUDINAL ORIENTATION

Specimen No.	Temperature, °F	Impact Energy, ft-lb	Lateral Expansion, mils	Fracture Appearance, Percent Shear
14E	-150	2.0	2.0	0
147	-100	3.0	4.5	0
145	-33	10.0	12.0	1
14D	-15	15.5	19.0	5
14C	+5	34.0	33.5	10
143	+21	49.0	45.0	15
171	+49	77.5	63.0	25
172	+49	67.0	54.5	20
173	+49	90.0	67.0	25
146	+50	69.0	56.0	25
141	+72	94.0	75.0	50
14A	+110	129.5	88.0	80
142	+150	135.5	93.5	100
14B	+225	162.5	85.5	100
144	+294	143.0	94.0	100
14J	+360	178.0	78.0	100

TABLE 4. CHARPY V-NOTCH IMPACT RESULTS FOR BASE METAL PLATE NO. D3803-1, TRANSVERSE ORIENTATION

Specimen No.	Temperature, °F	Impact Energy, ft-lb	Lateral Expansion, mils	Fracture Appearance, Percent Shear
23P	-150	2.0	2.5	0
21E	-100	4.0	4.0	0
21B	-33	11.0	13.5	2
23M	-15	12.0	16.0	5
23L	+5	41.5	38.5	10
217	+21	27.0	29.0	15
21D	+50	46.0	44.0	20
215	+72	60.0	53.5	30
23T	+90	68.5	58.0	50
23J	+110	94.0	75.0	80
216	+150	114.0	79.0	100
23K	+225	107.0	79.0	100
21A	+295	92.0	75.5	100
252	+296	102.0	81.5	100
23U	+360	93.0	78.0	100

TABLE 5. CHARPY V-NOTCH IMPACT RESULTS FOR WELD METAL

Specimen No.	Temperature, °F	Impact Energy, ft-lb	Lateral Expansion, mils	Fracture Appearance, Percent Shear
36T	-170	4.0	5.0	0
36J	-150	7.0	7.0	0
36P	-135	14.5	14.5	2
367	-100	8.5	11.0	1
36M	-100	31.0	28.0	5
36L	-85	35.0	33.5	10
36E	-75	47.5	41.0	15
36D	-50	41.0	39.0	20
365	-33	56.0	52.0	30
36C	-5	87.0	75.0	60
363	+20	86.0	77.0	80
366	+50	92.0	79.0	80
361	+72	96.0	85.0	90
36A	+110	117.5	94.0	100
362	+150	112.0	88.5	100
36B	+225	127.5	92.0	100
364	+296	111.0	87.0	100
35K	+360	120.5	91.5	100

TABLE 6. CHARPY V-NOTCH IMPACT RESULTS FOR HAZ METAL

Specimen No.	Temperature, °F	Impact Energy, ft-lb	Lateral Expansion, mils	Fracture Appearance, Percent, Shear
47Y	-170	5.0	4.0	0
471	-150	5.0	3.0	0
43A	-145	6.0	5.0	0
475	-137	6.0	3.5	2
474	-135	13.0	10.0	1
473	-120	15.0	11.0	5
476	-109	20.0	15.0	5
477	-101	25.0	18.5	10
467	-100	64.0	43.0	15
41A	-75	13.0	13.5	5
465	-34	76.5	56.0	40
463	+20	77.0	45.5	50
466	+50	94.0	71.0	85
461	+72	112.0	76.5	80
46A	+110	90.0	74.0	100
462	+151	114.0	81.0	100
46C	+225	120.0	86.0	100
464	+296	138.5	87.0	100
472	+360	115.0	75.0	100

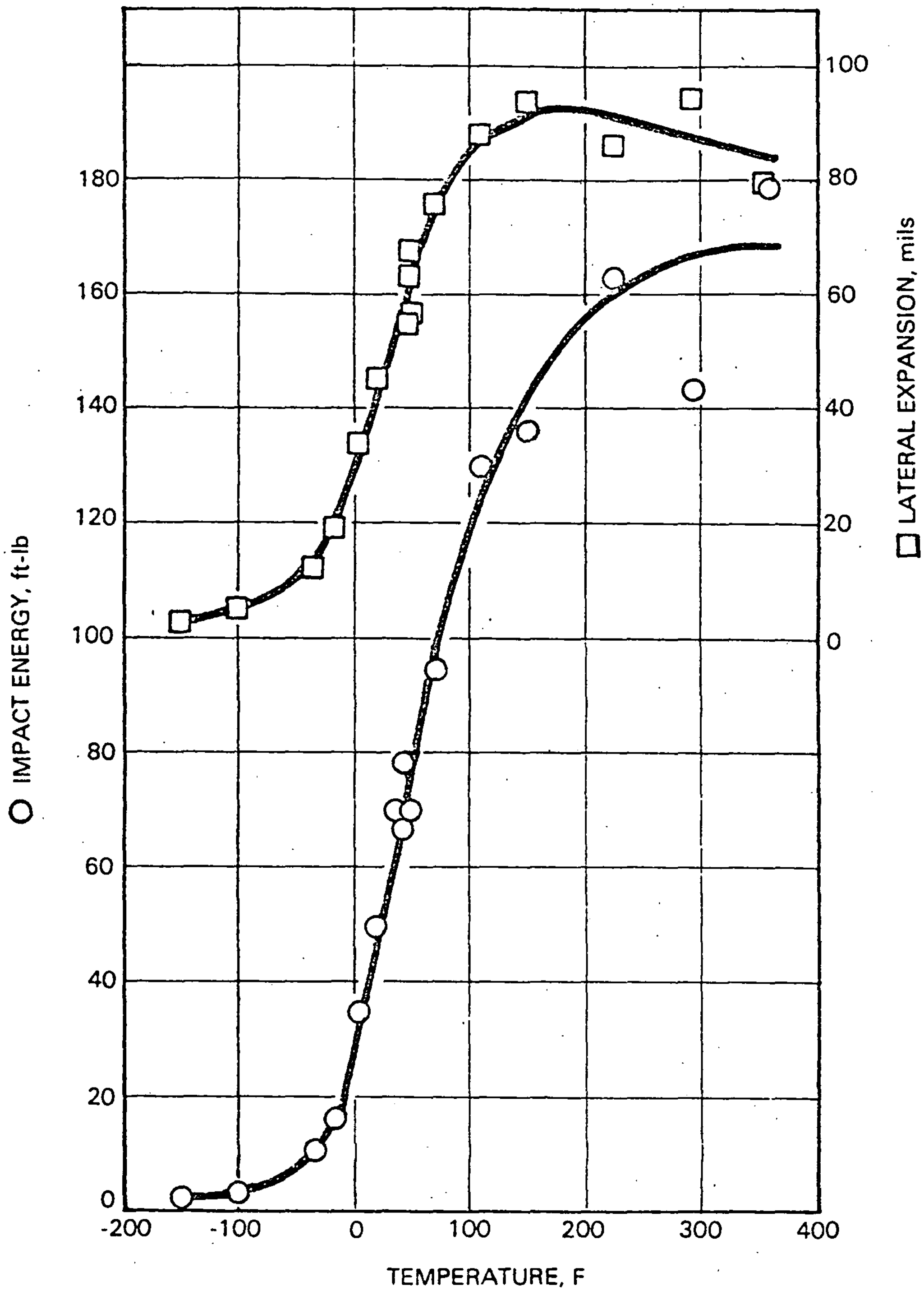


FIGURE 10. CHARPY IMPACT PROPERTIES FOR BASE METAL, PLATE NO. D3803-1, LONGITUDINAL ORIENTATION

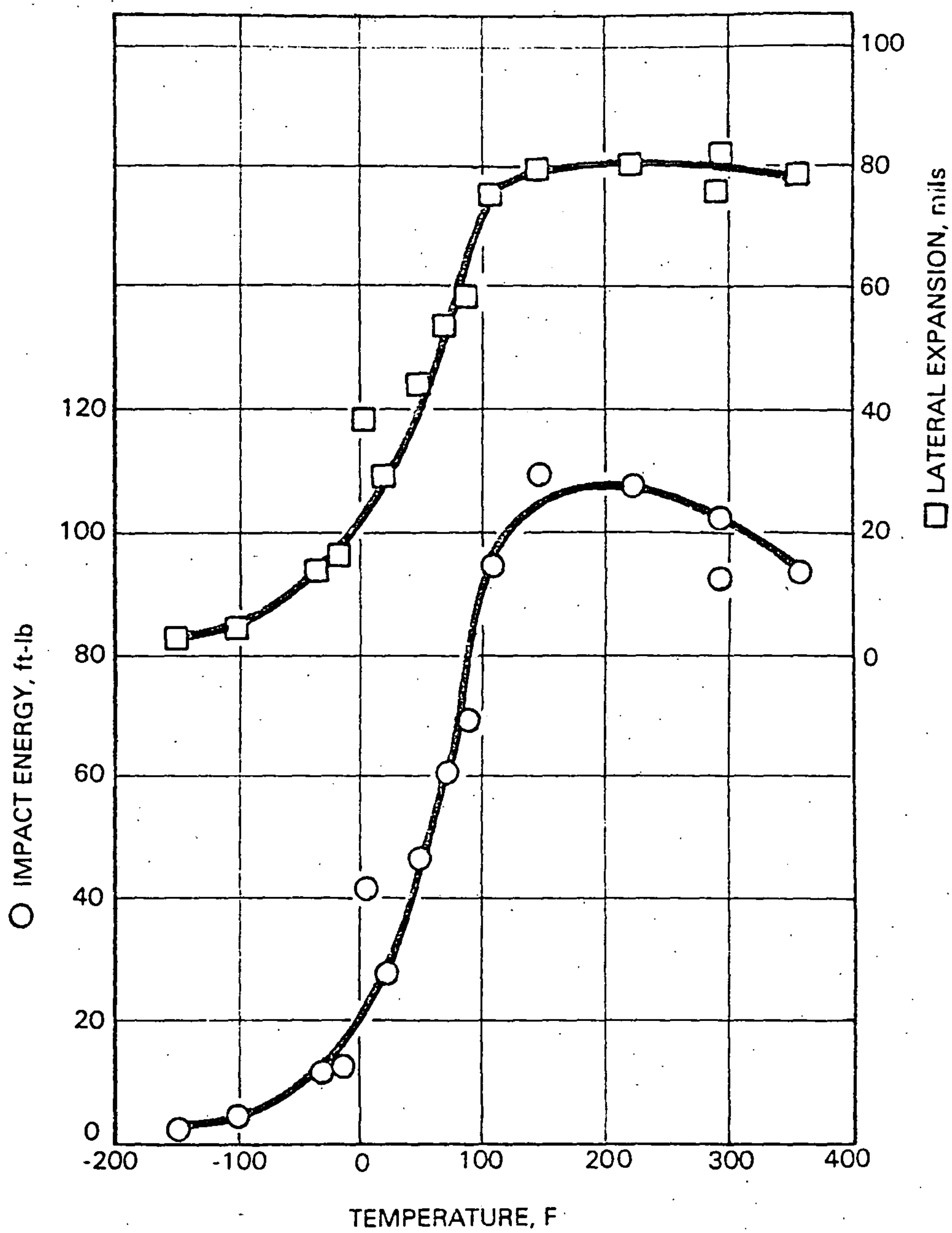


FIGURE 11. CHARPY IMPACT PROPERTIES FOR BASE METAL, PLATE NO. D3803-1, TRANSVERSE ORIENTATION

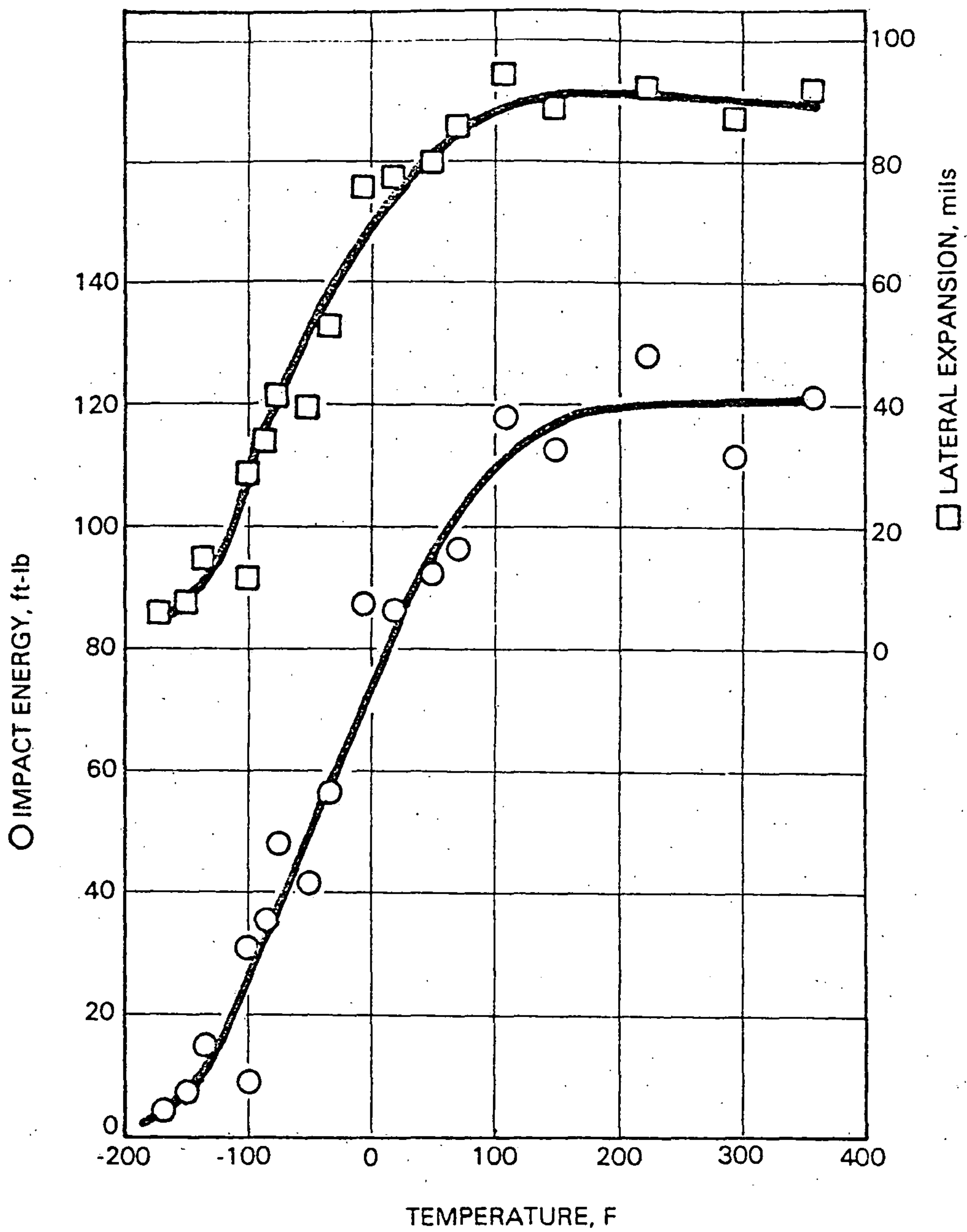


FIGURE 12. CHARPY IMPACT PROPERTIES FOR WELD METAL

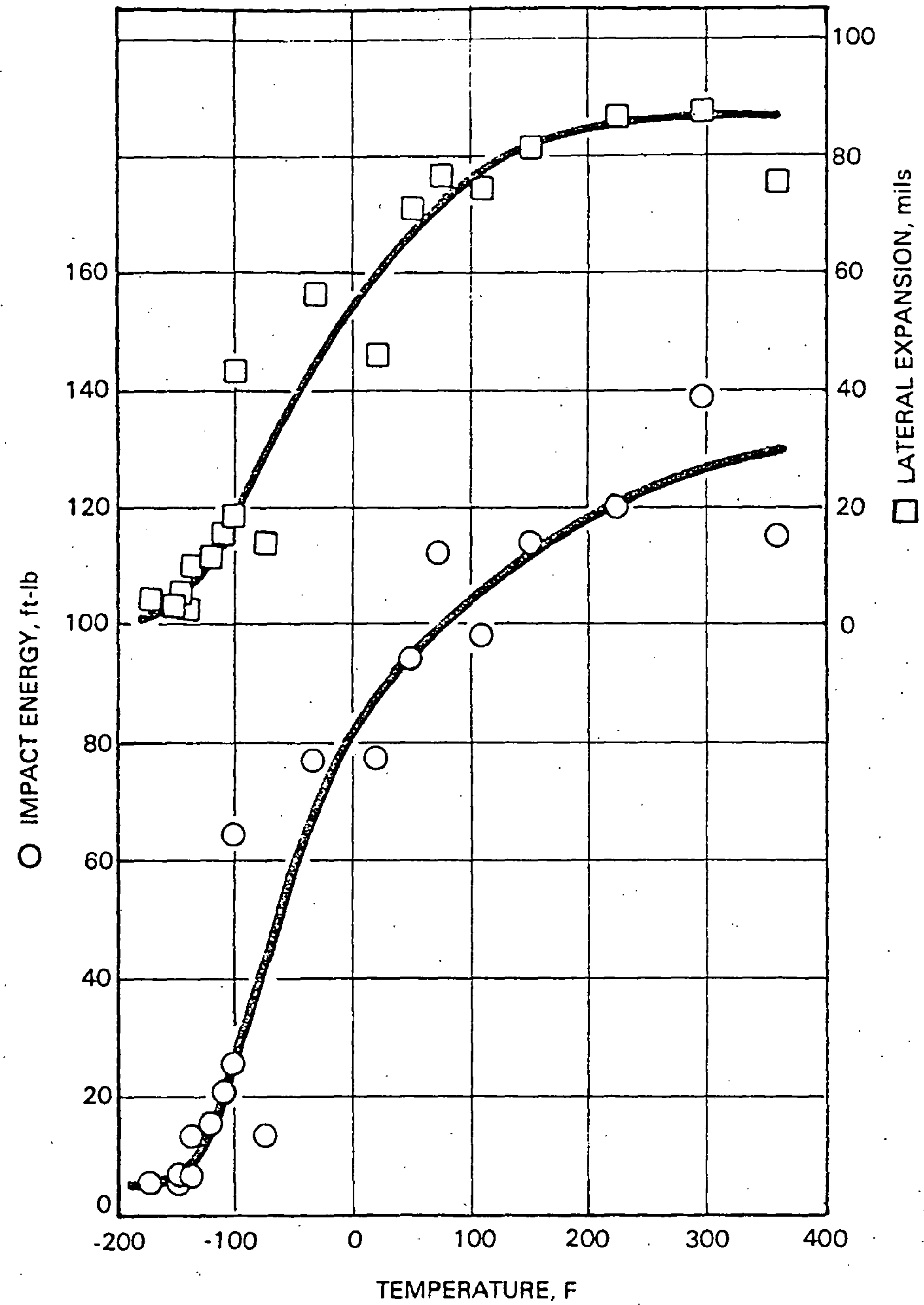
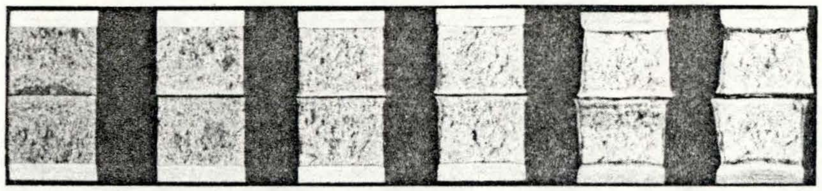


FIGURE 13. CHARPY IMPACT PROPERTIES FOR HEAT AFFECTED ZONE METAL

TABLE 7. UPPER SHELF ENERGY AND TRANSITION TEMPERATURE FOR PALISADES

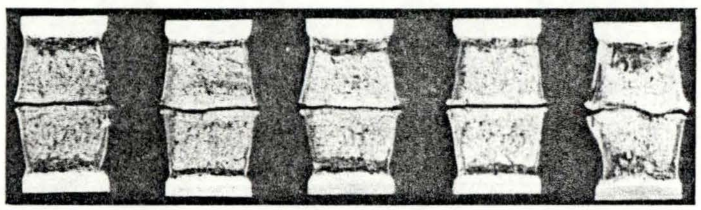
Material	30 ft-lb Transition Temperature, F	50 ft-lb Transition Temperature, F	Upper Shelf Energy, ft-lb
Base (Longitudinal)	0	+20	165
Base (Transverse)	+25	+55	105
Weld Metal	-85	-50	120
HAZ Metal	-90	-65	125

Specimen No. 14E 147 145 14D 14C 143



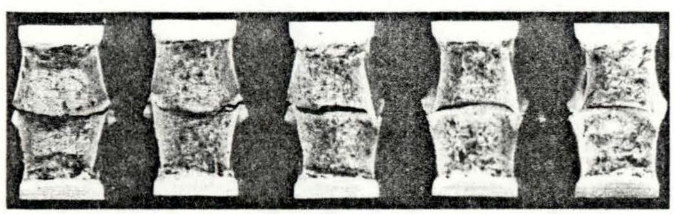
Test Temperature, °F -150 -100 -33 -15 +5 +21

Specimen No. 171 172 173 146 141



Test Temperature, °F +49 +49 +49 +50 +72

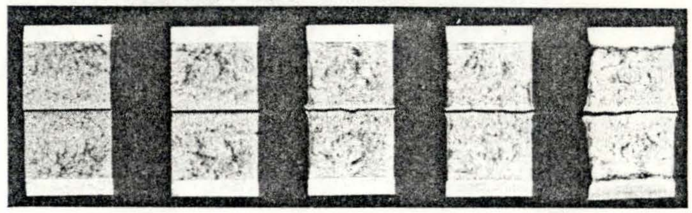
Specimen No. 14A 142 14B 144 14J



Test Temperature, °F +110 +150 +225 +294 +360

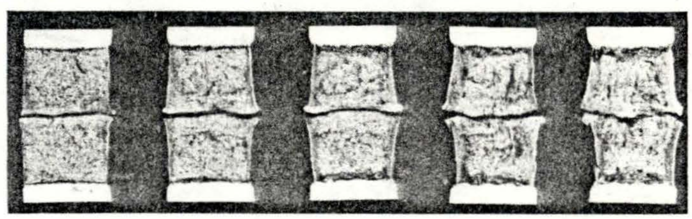
FIGURE 14. CHARPY IMPACT SPECIMEN FRACTURE SURFACES FOR BASE METAL, PLATE NO. D3803-1, LONGITUDINAL ORIENTATION

Specimen No. 23P 21E 21B 23M 23L



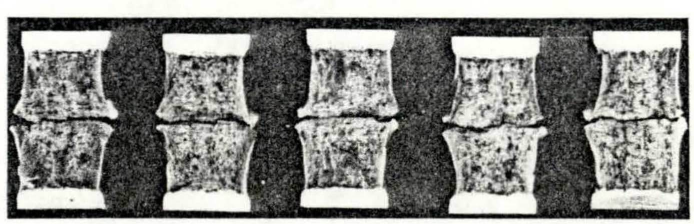
Test Temperature, °F -150 -100 -33 -15 +5

Specimen No. 217 21D 215 23T 23J



Test Temperature, °F +21 +50 +72 +90 +110

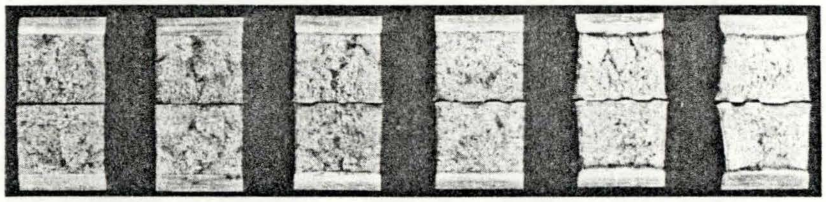
Specimen No. 216 23K 21A 252 23U



Test Temperature, °F +150 +225 +295 +296 +360

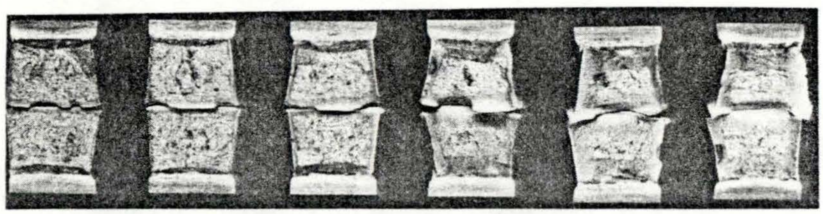
FIGURE 15. CHARPY IMPACT SPECIMEN FRACTURE SURFACES FOR BASE METAL, PLATE NO. D3803-1, TRANSVERSE ORIENTATION

Specimen No.	36T	36J	36P	367	36M	36L



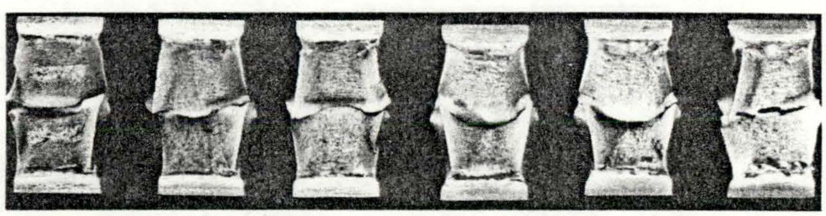
Test Temperature, °F	-170	-150	-135	-100	-100	-85

Specimen No.	36E	36D	365	36C	363	366



Test Temperature, °F	-75	-50	-33	-5	+20	+50

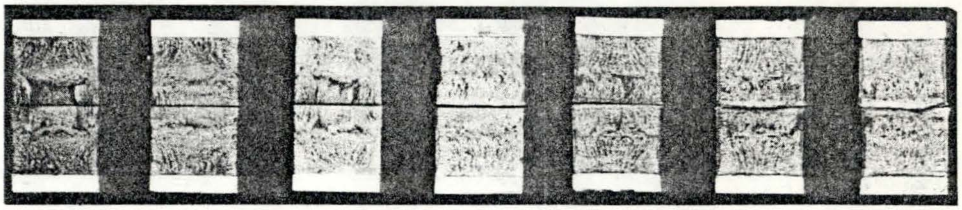
Specimen No.	361	36A	362	36B	364	35K



Test Temperature, °F	+72	+110	+150	+225	+296	+360

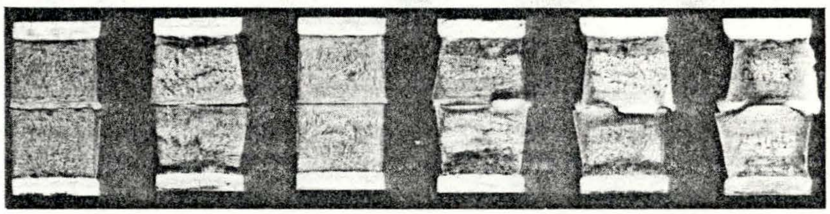
FIGURE 16. CHARPY IMPACT SPECIMEN FRACTURE SURFACES FOR WELD METAL

Specimen No.	47Y	471	43A	475	474	473	476



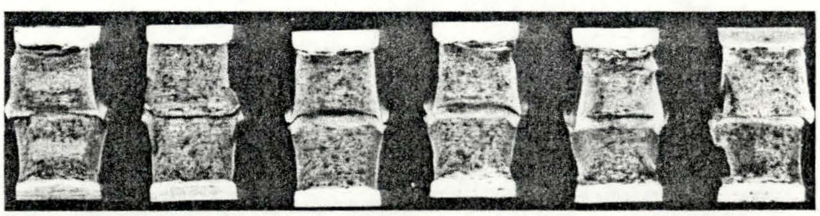
Test Temperature, °F	-170	-150	-145	-137	-135	-120	-109

Specimen No.	477	467	41A	465	463	466



Test Temperature, °F	-101	-100	-75	-34	+20	+50

Specimen No.	461	46A	462	46C	464	472



Test Temperature, °F	+72	+110	+151	+225	+296	+360

FIGURE 17. CHARPY IMPACT SPECIMEN FRACTURE SURFACES FOR HAZ METAL

The fracture surface shows large shear lips with a 100% shear fracture appearance. The specimen absorbed a relatively large amount of energy, 135 ft-lb during impact. The substantial amount of plastic deformation occurring during this test is reflected in the large value of 93.5 mils lateral expansion.

The NDT temperature as found from the drop weight test for the base longitudinal material was -10 F. The reference temperature, RT_{NDT}, was established according to paragraph NB-2331 of the ASME Code.[13] The RT_{NDT} is established as follows: at a temperature not greater than NDT +60 F, each of three Charpy V-notch specimens tested must exhibit at least 35 mils lateral expansion and not less than 50 ft-lb of absorbed energy. When these requirements are met the NDT is the reference temperature.

Triplicate base longitudinal specimens were tested at 49 F to establish the RT_{NDT}. As seen from Table 3, all three specimens (171, 172, and 173) met the above criteria. Consequently, the NDT temperature of -10 F is also the reference temperature RT_{NDT}.

Tensile Properties

The preirradiation tensile properties determined as a function of temperature are listed in Tables 8 through 11. The tables list the test temperature, 0.2 percent offset yield strength, ultimate tensile strength, uniform elongation, total elongation, and reduction in area. A typical tensile test curve is shown in Figure 18; the particular curve shown is for base metal specimen 1JC tested at 565 F. Posttest photographs of the tensile specimens are shown in Figures 19 through 30.

Tensile tests were run at room temperature, 535 and 565 F. The higher temperature tests exhibited a decrease in the 0.2 percent offset yield strength and a decrease in the ultimate tensile strength for each material. In general, ductility values (as determined by total elongation and reduction in area) were lower at 535 and 565 F than at 75 F for each material.

The three HAZ specimens tested at 75 F all fractured near one end of the gage length. All other specimens including the high temperature HAZ specimens, fractured at or close to the center of the gage length. There is no obvious explanation for the behavior observed for the three room temperature HAZ specimens.

TABLE 8. PREIRRADIATION TENSILE PROPERTIES OF BASE METAL, PLATE NO. D3803-1, LONGITUDINAL ORIENTATION

Specimen No.	Temp, F	0.2 Percent Offset Yield Strength, psi	Ultimate Tensile Strength, psi	Elongation, Percent Uniform	Elongation, Percent Total	Reduction in Area, Percent
1E1	70	64,270	85,700	15.4	30.7	72.3
1E2	70	63,920	85,200	15.6	31.2	72.7
1E3	70	63,170	85,720	16.3	30.9	71.3
1DM	535	57,170	82,720	12.3	23.3	64.5
IDP	535	57,580	82,470	11.8	23.1	64.8
IDI	535	57,490	82,180	11.8	23.1	64.6
IJA	565	58,840	84,920	13.0	24.3	62.6
IJB	565	57,860	84,350	13.7	25.2	68.6
IJC	565	58,340	84,510	14.2	26.2	67.7

TABLE 9. PREIRRADIATION TENSILE PROPERTIES OF BASE METAL, PLATE NO. D3803-1, TRANSVERSE ORIENTATION

Specimen No.	Temp, F	0.2 Percent Offset Yield Strength, psi	Ultimate Tensile Strength, psi	Elongation, Percent		Reduction in Area, Percent
				Uniform	Total	
2D1	70	65,180	86,640	16.0	29.6	68.2
2D2	70	65,350	86,990	15.3	29.0	68.2
2D3	70	65,040	86,990	14.7	28.5	68.4
2DE	535	57,740	81,840	12.2	25.8	63.8
2DJ	535	57,630	82,280	11.8	16.3	33.9
2DK	535	57,630	82,380	11.6	17.8	42.4
2DA	565	57,220	84,210	14.7	25.7	63.1
2DB	565	56,920	83,800	13.9	21.8	42.7
2DC	565	58,360	83,780	13.9	23.9	57.5

TABLE 10. PREIRRADIATION TENSILE PROPERTIES OF WELD METAL

Specimen No.	Temp, F	0.2 Percent Offset Yield Strength, psi	Ultimate Tensile Strength, psi	Elongation, Percent Uniform	Elongation, Percent Total	Reduction in Area, Percent
3E1	70	64,980	82,190	17.2	32.0	68.9
3E2	70	63,490	81,540	17.2	32.3	70.3
3E3	70	64,330	82,010	17.7	32.6	71.0
3E5	535	64,630	86,470	13.5	21.6	56.4
3E6	535	63,100	83,900	12.8	21.9	57.0
3E7	535	63,320	83,420	11.9	21.3	53.8
3EA	565	59,640	82,760	13.7	24.7	63.8
3EB	565	61,060	84,220	13.7	21.9	49.3
3EC	565	60,800	84,960	13.2	22.7	54.8

TABLE 11. PREIRRADIATION TENSILE PROPERTIES OF HAZ METAL

Specimen No.	Temp, F	0.2 Percent Offset Yield Strength, psi	Ultimate Tensile Strength, psi	Elongation, Percent Uniform	Elongation, Percent Total	Reduction in Area, Percent
4E1	70	63,180	84,380	15.3	28.5	66.2
4E2	70	63,860	84,480	15.7	30.2	69.5
4E3	70	63,950	84,450	15.4	30.1	71.3
4E4	535	59,060	81,590	12.5	22.9	61.8
4E5	535	58,110	81,970	12.5	23.0	66.6
4E6	535	57,730	82,180	12.4	21.3	64.7
4J1	565	56,790	82,900	14.4	24.9	63.7
4J2	565	55,260	81,930	13.9	25.4	65.3
4J3	565	55,090	82,280	14.2	25.5	66.2

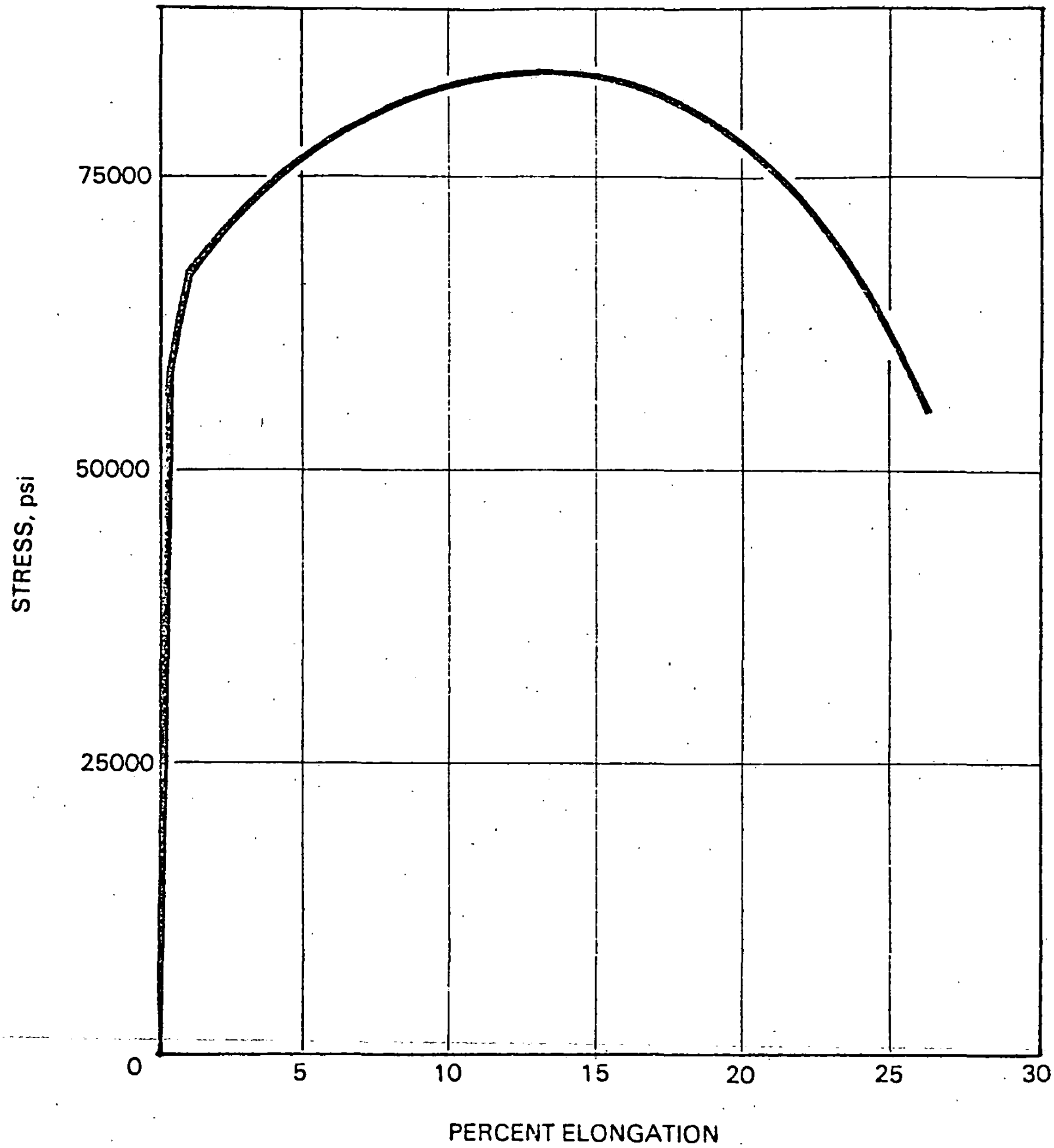
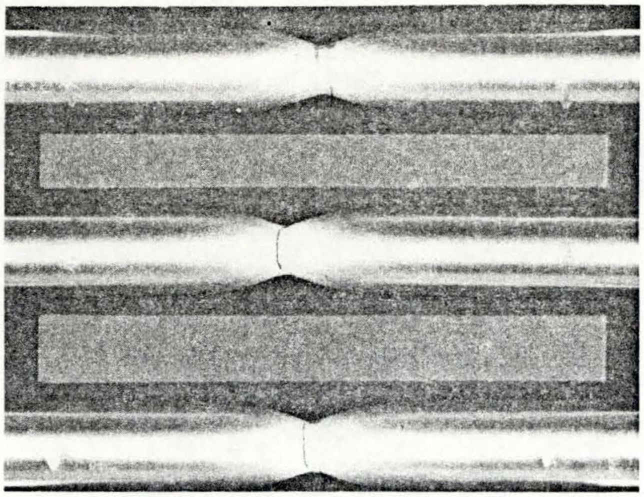


FIGURE 18. TYPICAL STRESS-STRAIN CURVE

Curve shown is for base metal specimen 1JC, longitudinal orientation, tested at 565 F.

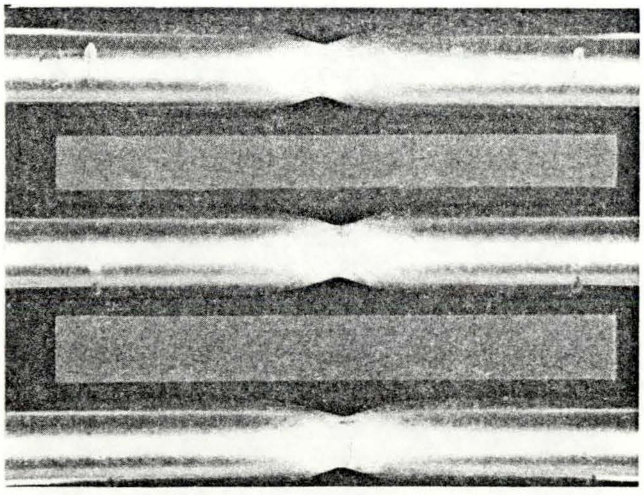


Specimen 1E1

Specimen 1E2

Specimen 1E3

FIGURE 19. POSTTEST PHOTOGRAPHS OF TENSILE SPECIMENS TESTED AT 70 F, BASE METAL, LONGITUDINAL ORIENTATION

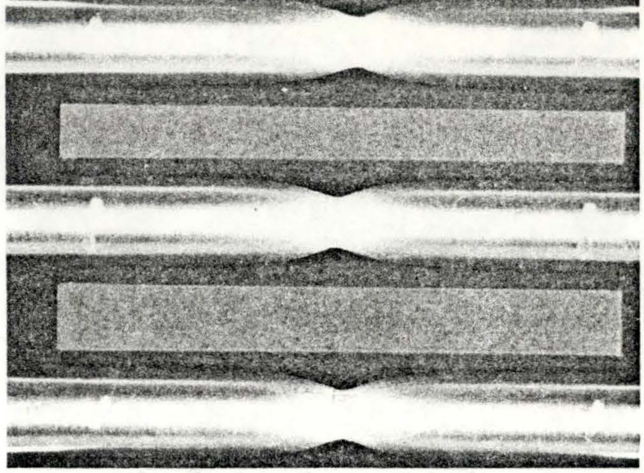


Specimen 2D1

Specimen 2D2

Specimen 2D3

FIGURE 20. POSTTEST PHOTOGRAPHS OF TENSILE SPECIMENS TESTED AT 70 F, BASE METAL, TRANSVERSE ORIENTATION

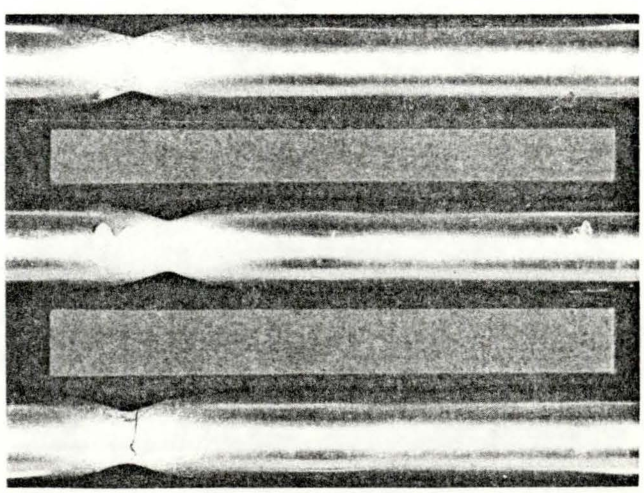


Specimen 3E1

Specimen 3E2

Specimen 3E3

FIGURE 21. POSTTEST PHOTOGRAPHS OF TENSILE SPECIMENS TESTED AT 70 F, WELD METAL

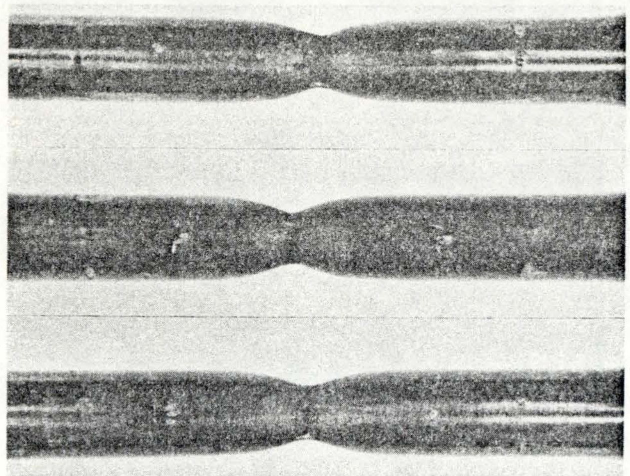


Specimen 4E1

Specimen 4E2

Specimen 4E3

FIGURE 22. POSTTEST PHOTOGRAPHS OF TENSILE SPECIMENS TESTED AT 70 F, HAZ METAL

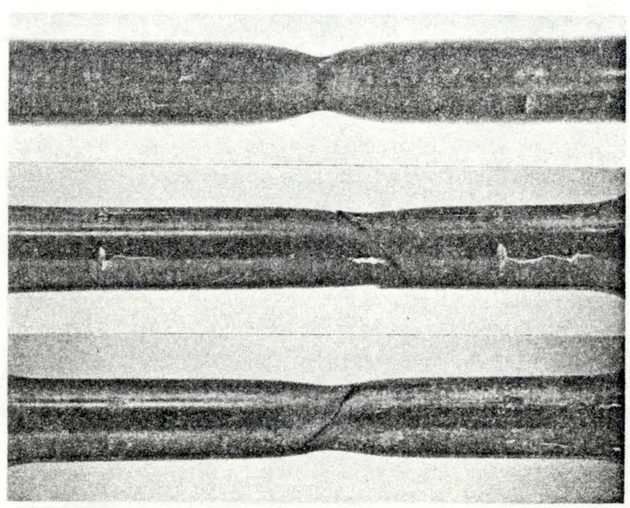


Specimen 1DM

Specimen 1DP

Specimen 1DT

FIGURE 23. POSTTEST PHOTOGRAPHS OF TENSILE SPECIMENS TESTED AT 535 F, BASE METAL, LONGITUDINAL ORIENTATION

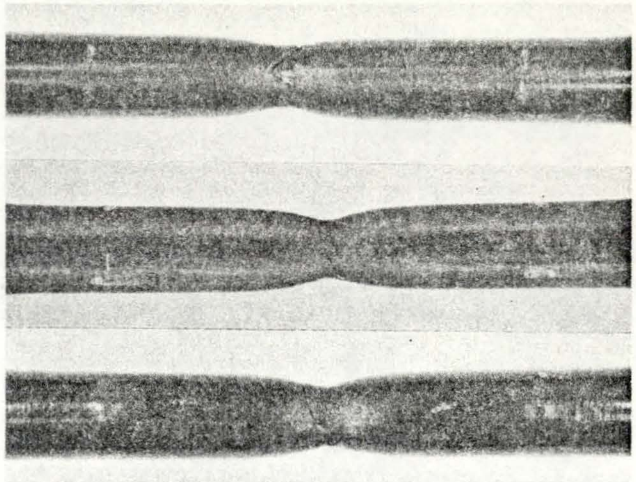


Specimen 2DE

Specimen 2DJ

Specimen 2DK

FIGURE 24. POSTTEST PHOTOGRAPHS OF TENSILE SPECIMENS TESTED AT 535 F, BASE METAL, TRANSVERSE ORIENTATION

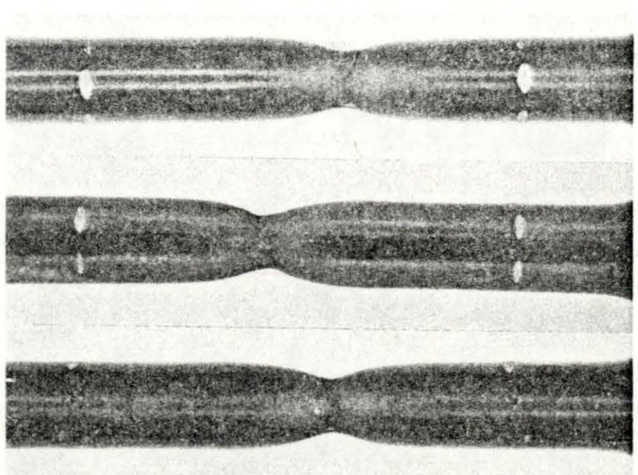


Specimen 3E5

Specimen 3E6

Specimen 3E7

FIGURE 25. POSTTEST PHOTOGRAPHS OF TENSILE SPECIMENS TESTED AT 535 F, WELD METAL

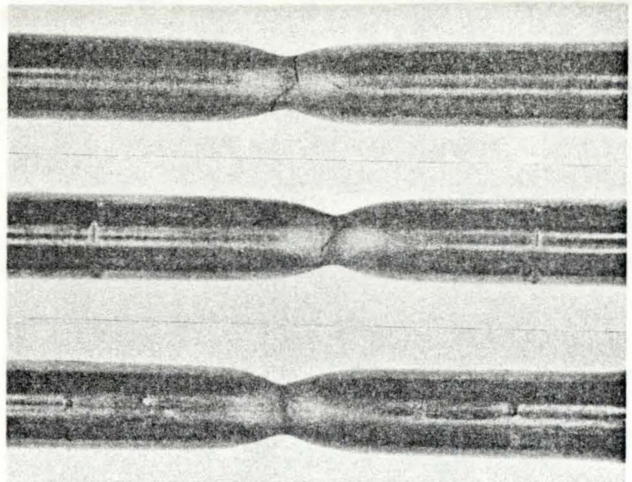


Specimen 4E4

Specimen 4E5

Specimen 4E6

FIGURE 26. POSTTEST PHOTOGRAPHS OF TENSILE SPECIMENS TESTED AT 535 F, HAZ METAL

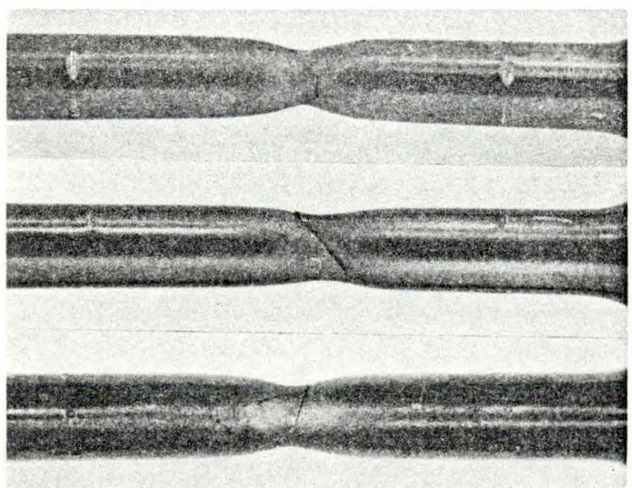


Specimen 1JA

Specimen 1JB

Specimen 1JC

FIGURE 27. POSTTEST PHOTOGRAPHS OF TENSILE SPECIMENS TESTED AT 565 F, BASE METAL, LONGITUDINAL ORIENTATION

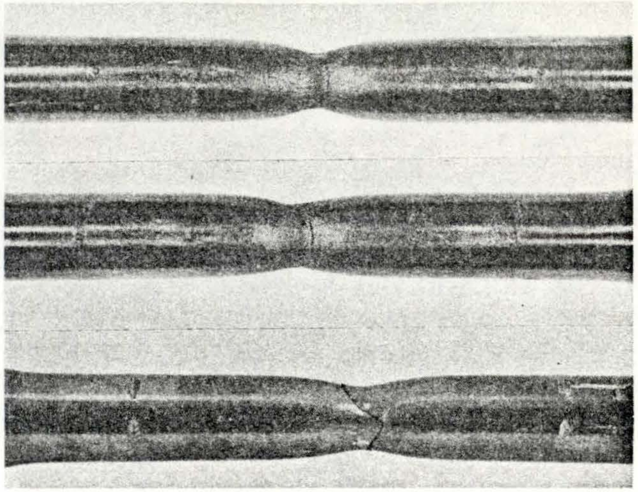


Specimen 2DA

Specimen 2DB

Specimen 2DC

FIGURE 28. POSTTEST PHOTOGRAPHS OF TENSILE SPECIMENS TESTED AT 565 F, BASE METAL, TRANSVERSE ORIENTATION

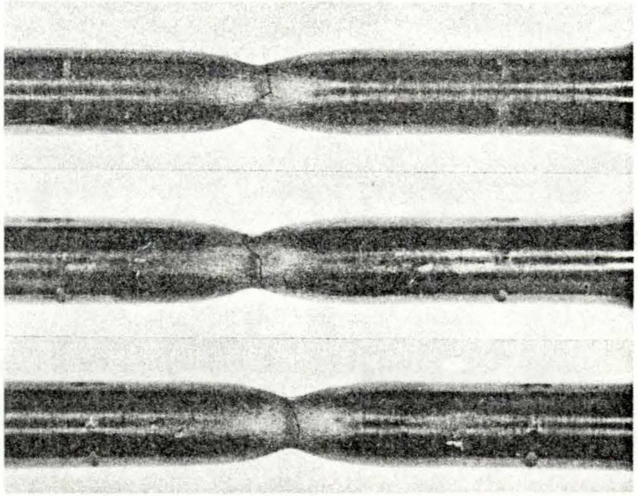


Specimen 3EA

Specimen 3EB

Specimen 3EC

FIGURE 29. POSTTEST PHOTOGRAPHS OF TENSILE SPECIMENS TESTED AT 565 F, WELD METAL



Specimen 4J1

Specimen 4J2

Specimen 4J3

FIGURE 30. POSTTEST PHOTOGRAPHS OF TENSILE SPECIMENS TESTED AT 565 F, HAZ METAL

CONCLUSIONS

The drop weight properties of base metal longitudinal orientation and the Charpy impact and tensile properties of base metal longitudinal and transverse orientations have been determined. The data generated fell in the general range of values to be expected for these materials.

The NDT temperature for the base metal (longitudinal orientation) as established from the drop weight test was -10 F. The corresponding reference temperature RT_{NDT} for the same material as determined by Charpy tests was also -10 F. The upper shelf energy levels range from 105 ft-lb for the base metal transverse orientation to 165 ft-lb for the base metal longitudinal orientation material.

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(9) ASTM Designation E185-73, "Surveillance Tests on Structural Materials in Nuclear Reactors", Book of ASTM Standards, Part 10 (1976), pp 314-320.

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(12) ASTM Designation A370-75, "Mechanical Testing of Steel Products", Book of ASTM Standards, Part 10 (1976), pp 28-79.

(13) ASME Boiler and Pressure Vessel Code, Section III, Division, Rules for Construction of Nuclear Power Plant Components, Subsection NB, Class 1 Components, 1974 Edition.

APPENDIX A

COMPOSITIONAL ANALYSIS OF SURVEILLANCE TEST MATERIALS

APPENDIX A

COMPOSITIONAL ANALYSIS OF SURVEILLANCE TEST MATERIALS

The sample chemical analyses of the surveillance test materials for the three plates and two welds that make up the surveillance program as reported by Combustion Engineering[8] are given in Table A-1.

The base metal test material was fabricated from Plate No. D3803-1. The weld metal test material was fabricated by welding together intermediate shell Plate Nos. D3803-1 and D3803-2. The heat-affected-zone test material was fabricated by welding together intermediate shell Plate Nos D3803-2 and D3803-3.

TABLE A-1. SAMPLE CHEMICAL ANALYSIS OF SURVEILLANCE TEST MATERIALS

Elements	D-3803-1[(a)] Plate	D-3803-2 Plate	D-3803-3 Plate	D-3803-3/ D-3803-2[(b)] Weld @ 2 in.		D-3803-2/ D-3803-1[(c)] Weld @ 2 in.	
				Root	Face	Root	Face
Si	.23	.32	.24	.24	.25	.25	.22
S	.019	.021	.020	.009	.010	.010	.010
P	.011	.012	.010	.011	.012	.011	.011
Mn	1.55	1.43	1.56	1.08	1.03	1.01	1.02
C	.22	.23	.21	.098	.080	.088	.086
Cr	.13	.42	.13	.05	.04	.05	.03
Ni	.53	.55	.53	.43	1.28	.63	1.27
Mo	.58	.58	.59	.54	.53	.55	.52
Al	.037	.022	.037	Nil	Nil	Nil	Nil
V	.003	.003	.003	Nil	Nil	Nil	Nil
Cu	.25	.25	.25	.25	.20	.26	.22

(a) Used to fabricate base metal specimens.

(b) Used to fabricate HAZ metal specimens.

(c) Used to fabricate weld metal specimens.

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September 16, 1977

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I am enclosing the two documents I spoke of in our conversation of last Thursday. These documents are the Battelle report on our unirradiated baseline surveillance specimens and the US AEC Regulatory Standard Review Plan 5.3.2. The Standard Review Plan is supplemented by Branch Technical Position MTEB 5-2 which prescribes certain fracture toughness requirements for older plants.

Based upon Battelle test data, the NDT temperature for the longitudinally oriented base metal specimens is -10°F. The reference temperature is the same based upon Charpy V-Notch results. However, the Consumers Power Co baseline specimen package from CE does not contain transverse drop weight specimens. This implies that the transverse Charpy V-Notch data are controlling and serve to define the base metal reference temperature. From the MTEB 5-2 section A.1.1(1), the reference temperature for our specimens would appear to default to the transverse Charpy V-Notch 30 ft lb valve of 25°F.

It is our judgment that such a value is unreasonable. We would like to be advised of any technical basis which might exist for adopting a less restrictive reference temperature.

Any information which you could provide would be very much appreciated.

Rolfe Jenkins

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Operating Services Dept

JENK 39-77